STUDIES ON THE BIOLOGY OF SOME CARPS

ABSTRACT

THESIS SUBMITTED FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

TO THE

Aligarh Muslim University, Aligarh

1594

By

ANIL K. CHATTERJI

M. Sc., M. Phil. (Alig.)

DEPARTMENT OF ZOOLOG.

ALIGARH MUSLIM UNIVERSITY

ALIGARH

JUNE, 1976

ABSTRACT

During the present investigation which was carried out for two years from October 1972 to October 1974, some aspects of the biology of Labeo bata (Ham.) and Labeo gonius (Ham.) like, morphometry, length-weight relationships, condition factor, age and growth, food and feeding habits and reproduction of these two species in river Kali, which is a major source of fish supply at Aligarh, were studied.

For morphometric studies, the samples were collected from two different environments, the river Kali and a pond Chau Tal. The characters selected for the study were total length, standard length, head length, body length, depth at pectoral fin base, depth at dorsal fin base and depth of the caudal peduncle. The regressions of different body measurements on total length were carried out and a linear relationship was noted in the fishes of both the environments. The various body proportions expressed as per cent of total length revealed that characters associated with length were higher in case of pond fishes while characters associated with depth were higher in riverine fishes than the pond fishes. However, the differences between the fishes of different years or sexes were not statistically significant.

The study of length-weight relationship of these two species revealed that this fish did not follow the cube law

strictly and the weight increase at a rate more than the cube of the length. No significant difference was noted in the value of 'n' by the analysis of covariance between the fishes of different size, sex and maturity stages in a population. The equation for length-weight relationship for L. bata and L. gonius are $W = 0.4893 \times 10^{-5} L^{3.1667}$ (combined fishes) and $W = 0.1512 \times 10^{-5} L^{3.7794}$ (combined fishes) respectively. The two length-weight curves of males and females intersected at a point between 250 mm and 270 mm in L. bata while 245 mm and 265 mm in L. gonius. This point of inter-section represents the size at first maturity of the fishes.

The relative condition factor 'Kn' was studied in different size groups, different maturity stages and during different months. The 'Kn' value was high in smaller size groups, thereafter, the value decreased and increased several times. The fishes were found to attain peak condition 3 times upto the length group of 450 mm in both the species. These peaks indicate the number of spawnings upto the length. Seasonal fluctuations in the condition are due to fluctuation in the gonad weight. High values coincide with the breeding season.

Age and growth of L. bata and L. gonius was studied by the analysis of scales and length frequency distribution. Scale pattern of these fishes shows the growth check in the form of carved out spaces in circuli. These circuli are annular in nature. L. bata was found to attain a length of 131 mm, 194 mm, 236 mm, 314 mm, 341 mm, and 364 mm at the end of Ist, 2nd, 3rd, 4th, 5th, 6th and 7th year of life respectively while L. gonius attained an average lengths of 142 mm, 206 mm, 239 mm, 264 mm, 285 mm and 300 mm at the end of Ist, 2nd, 3rd, 4th, 5th and 6th years respectively. Increase in length of the scale was observed to bear a constant ratio to the increase in length of the fish and regression analysis yielded a straight line relationship between the scale and body length. The calculated values could be expressed as $Y = -2.534 + 0.064\ X$ in L. bata and $Y = -1.2127 + 1.0850\ X$ in L. gonius.

The growth rate of the fishes was found to be high during Ist and 2nd years of life after which the rate decreased gradually upto the higher age groups. Both sexes showed a similar growth rate and attained a similar longevity.

The Von Bertalanffy's growth equation was found to describe adequately the actual growth of the species and could be expressed as $Lt = 450\ (1-e^{-0.2165(t + 0.5963)})$ for L. bata and $Lt = 449\ (1-e^{-0.2099(t + 0.6940)})$ for L. gonius. Seasonal growth curve was chiefly influenced by feeding intensity in the fishes of first year-class while in adult fishes the seasonal growth curve was affected by feeding intensity as well as maturation of gonads.

These fishes feed mainly on phytoplanktonic organisms. Diatoms, green algae, blue green algae, desmids, phytoflagellates, algal spores and zygotes and decayed organic matter were the main food items present in the gut. The stomach of all the fishes contained sand particles which were ingested while feeding at bottom.

The intensity of feeding was found to be maximum during post monsoon (Oct. and Nov.) and winter months (Dec. to Feb.) and low during post winter (March and April), summer (May and June) and monsoon months (July and August). The increased feeding intensity in winter correspond to a period of algal blooms in the water. During rainy season, the river gets flooded and contains less amount of food and this appears to influence the feeding intensity. Besides, the maturation of gonads was also found influencing the feeding intensity. No difference was noted between the food of males and females.

L. bata was definitely selective in feeding as the fingerlings showed a positive selection for all the zooplanktonic organisms while the adult showed a negative selection for all the zooplanktons and a positive selection for all the phyto-planktonic organisms.

Sex ratio, size and age at first maturity, maturation and spawning, breeding season and fecundity of *L. bata* and *L. gonius* were investigated. The population of these fishes showed a male: female sex ratio 1:1.42 (*L. bata*) and 1:1.86 (*L. gonius*). Males of *L. bata* matured at length of 180 mm and females at 190 mm while the males of *L. gonius* matured at the length of 170 mm while females matured at 180 mm.

Spawning occurs during July and August, the period of maximum precipitation and uniformity high temperature. Each individual contained only one stock of oocytes and spawned only once in a breeding season. Individual fecundity varied from 10,040 to 70,000 with an average of 192,785. Fecundity was found to be more closely related to ovary or body weight than length.

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DEPARTMENT OF ZOOLOGY
ALIGARH MUSLIM UNIVERSITY
ALIGARH., U. P. INDIA

Sections:
1 ENTOMOLOGY
2 PARASITOLOGY
3 ICHTHYOLOGY & FISHERIES
4 AGRICULTURAL NEMATOLOGY
5 GENETICS

Ref. No.

Date June 26, 1976

DECLARATION

This is to certify that Mr. Anil K. Chatterji has completed his research work under the supervision of Dr. A. Qayyum Siddiqui. But the work could not be submitted in the form of a thesis for the award of Ph.D. degree under him as he left Aligarh to take an assignment at Kenyatta University, Nairobi, Kenya. Now the thesis is being submitted under my direct supervision. The observational work recorded in this thesis was carried out by the candidate himself and I consider it a good piece of work with a considerable amount of addition in the existing knowledge on the biology of some carps. He is allowed to submit his thesis for the award of Ph.D. degree in Zoology of the Aligarh Muslim University, Aligarh.

Asif a-Khan

(Asif Ali Khan)
Ph.D.

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C O N T E N T S

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GENERAL INTRODUCTION

Fishes have great significance in the life of mankind, being an important source of protein food. In India fishery research is relatively a young science and its development is one of the recent scientific activities in this country. Fishery developmental research was originally started as an experiment in Bengal and Kerala during the early part of this century. After the second world war when the country suffered an acute food shortage, the significance of fishery science became obvious and many states then began to organise their own departments.

A review of the literature reveals that most of the earlier workers confined their studies on the marine food fishes as these fishes contribute a major portion of the total fish production of the country. Notable examples are those of sardine (Hornell and Naidu, 1924; Devanesan, 1932; Chidambaram, 1950; Nair, 1951; Vijayaraghavan, 1953 and 1955; Ganapati and Srinivasarao, 1957; Dhulkhed, 1962 and 1964; Radhakrishnan, 1964 and Kagwade, 1964), mackerels (Devanesan and John, 1940; Bhimachar and George, 1952; Pradhan, 1956; Balakrishnan, 1957; Radhakrishnan, 1962 and 1964; George and Banerjee, 1964 and Rao, 1964), seer fish (Vijayaraghavan, 1955; Krishnamoorthi, 1958), ribbon fish (Pradhan, 1955), Bombay duck (Bapat *et al*.

1951), malabar sole (Seshappa and Bhimachar, 1954 and 1955), thread fin (Mohammed, 1955 and Nayak, 1960) and ghol (Rao, 1963).

During recent years, many important publications on the biology of estuarine fishes have also appeared. The works on estuarine fishes include the contributions of Jacot (1920), Pillay (1954), Sarojini (1957 and 1958) and Luther (1963) on mullets and Chacko et al. (1948), Seshappa and Bhimachar (1951), Sujansinghani (1957), Pillay (1958) and Mathur (1964) on hilsa.

While considerable attention has been given to the management of fishes for increasing food production in India during the last two decades, it is surprising that the information on the biology of freshwater fishes, which are valuable culture species, is meagre. Raj (1951) gave a generalised account of the freshwater fishes of India. Preliminary studies on the breeding habits of the food fishes of Punjab and Bengal have been made by Khan, 1924, 1942; Hora, 1945; Mookerjee and Ghosh, 1945. The larval stages and life histories of some fishes have also been described (Alikunhi and Rao, 1947; Alikunhi, 1953, 1956 and Saigal, 1964). However, considerable attention has been given to the induced breeding of major carps and valuable informations have been made available (Khan, 1942; Mazumdar, 1945; Mookerjee, 1945; Alikunhi, 1953 and 1956; Chaudhury and Alikunhi, 1957). The technique of breeding of Indian carps by hypophysation has been reviewed by Alikunhi et al.

(1960), Chaudhuri (1960 and 1963), Das and Khan (1962), Bhimachar and Tripathi (1967), Jhingran (1969), Chondar (1970), Shehadeh (1970) and Tripathi and Bhimachar (1972).

Recently some aspects of the biology of few freshwater fishes have been reported. The age and growth of *Cirrhina mrigala* has been studied in detail (Jhingran, 1957 and 1959 and Kamal, 1969). Natarajan and Jhingran (1963) made a detailed study on the age and growth of *Catla catla*. The age and growth of *Setipinna phasa* (Jhingran, 1961) has also been reported.

Keeping in view the general paucity of information on the biology of important freshwater food fishes, attempts have been made at Aligarh to study the biology of fishes of the region. Some notable publications have already appeared on the biology of *Ophicephalus punctatus*, *Barbus stigma* and *Callichrous bimaculatus* (Qayyum and Qasim, 1964a, 1964b, 1964c). The spawning frequency and the extent of breeding seasons of a number of fish species and the fecundity of these fishes has been reported by Qasim and Qayyum (1961 and 1963). Khan (1972) studied in detail the biology of *Labeo rohita* and *Cirrhina mrigala* from different waters of Aligarh. In the same continuation the biology of two more important carps, *Labeo bata* (Ham.) and *Labeo gonius* (Ham.) has been investigated and reported here.

During the present investigation which was carried out for two years from October 1972 to October 1974, some aspects like, morphometry, length weight relationship, condition, age and growth, food and feeding habits and reproduction of these two species were studied and the same are reported here in the form of this thesis.

LABEO BATA:

Common name: Dunguda-porah, Dommarci-batta, Gootellah, Bango Tchirri and Bata.

Salient features: Body oblong, moderately compressed, snout blunt, lips thin and continuous, lower lip with shallow groove along their edge. Lower jaw with a tubercle on the inner side. A pair of very short maxillary barbels are present. Upper edge of dorsal fin concave. Lateral line scales 37 to 40. Maximum length is nearly two feet. Lower fin orange. All fins are with fine black spots. Colouration varying with age (Plate A).

Geographical distribution: Found in freshwater rivers and lakes. Distributed throughout North India and upto Kistna and Godavery rivers (Day, 1878) in the South.

LABEO GONIUS:

Common name: Cursua, Kurchi, Khursa, Goni, Bahtoor.

Salient features: Body oblong, moderately compressed, mouth rather narrow, its width equally 3½ in the length of the head, no lateral lobes but numerous pores are present on the snout. Lips thick and with distinct inner fold in their entire circumference both of which are fringed. Minute rostral and maxillary barbels are present. The dorsal profile is more convex than that of abdomen. Lateral line scales from 74 to 84. Attains a maximum length of nearly 5 ft. The colour of body is greenish along the back, becoming lighter on the sides, scale darkest at their margins, having red lunules on them (Day, 1878). Black longitudinal bands extend from the anterior end to the posterior end (Plate B).

Geographical distribution: Found in freshwater rivers and lakes, distributed throughout Northern and Western Provinces, Bengal and Orissa to Ganjam, as low as the Kistna, Assam, Burma and Pakistan (Day, 1878).

PLATE A. *Labeo bata* (Hamilton)

Showing different body measurements used in morphometric studies.

T.L. = Total length

S.L. = Standard length

B.L. = Body length

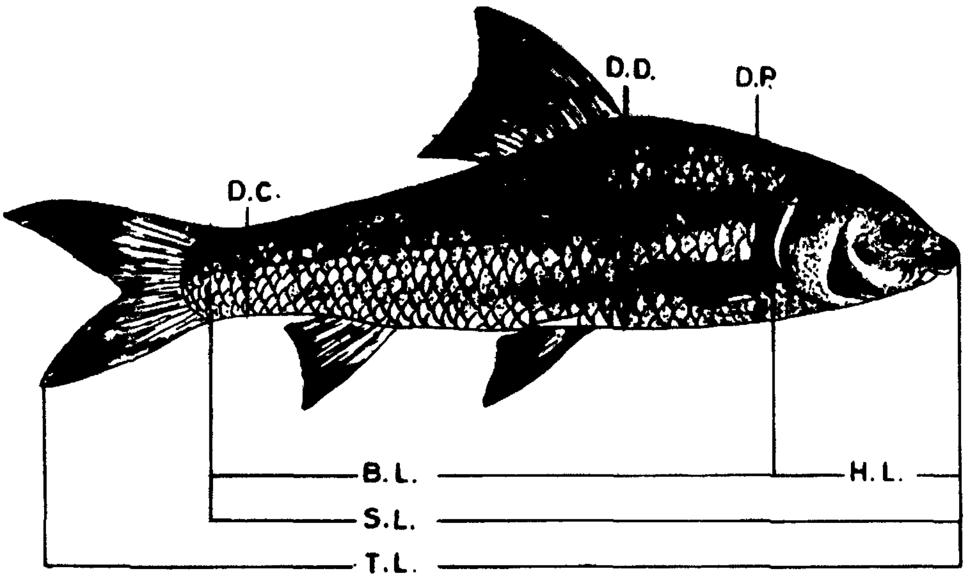
D.P. = Depth through pectoral fin base

D.D. = Depth through dorsal fin base

D.C. = Depth of the caudal peduncle .

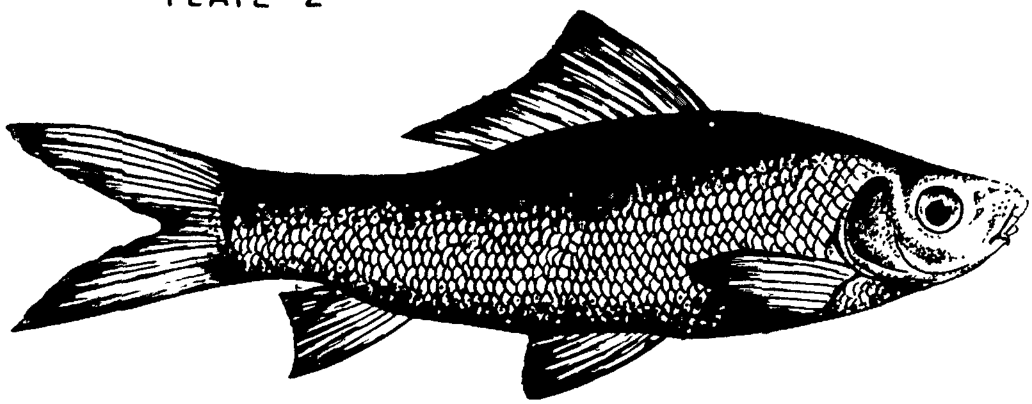
PLATE B. *Labeo gonius* (Hamilton)

PLATE 1



LABEO BATA (HAM.)

PLATE 2



LABEO GONIUS (HAM.)

PART I

THE BIOLOGY OF LABEO BATA (HAM.)

CHAPTER I

MORPHOMETRIC STUDIES

INTRODUCTION

Fishes of different stocks, races or populations show slight but significant changes in their morphometric measurements. These differences in a particular character of a population or stock can not be judged easily and hence statistical methods are employed to test the significance of these differences.

In the present study attempts have been made to establish a relationship between various body measurements to total length of Labeo bata (Ham.) collected from different environments and the application of covariance analysis to test the significance of differences between the populations.

MATERIALS AND METHODS

The samples for morphometric studies were obtained from two environments, the River Kali and a pond Chau Tal. The fishes of different environments were measured to the nearest mm and the following body proportions were selected (Plate A).

1. Total length: From the tip of the snout to the tip of the longest fin ray of caudal fin (T.L.).
2. Standard length: From the tip of the snout to the end of caudal peduncle (S.L.).
3. Head length: From the tip of the snout to the most posterior margins of sub-opercle (H.L.).

4. Body length: From the posterior part of the margin of sub-opercle to the deepest zone of caudal peduncle (B.L.).
5. Depth through pectoral fin base: Depth of the body at the origin of pectoral fin (D.P.).
6. Depth through dorsal fin base: Depth of the body at the origin of the dorsal fin (D.D.).
7. Depth of the caudal peduncle: The depth at the deepest zone of caudal peduncle (D.C.).

The total length of each specimen was used as a basis of reference for all other measurements (Carlander and Smith, 1945; Hile, 1948). A linear regression of various body proportions against total length was carried out by the least squares method. The measurements of all the characters were expressed as percent of total length. To determine the significance of differences, the regression of various body characters on total length of different groups were compared by using the covariance techniques (Mather, 1964).

RESULTS

The regression analysis of different measurements on total length and their significance has been tabulated in Tables 1, 2, 3 and 4. A straight line relationship was obtained in each case (Figs. 1 & 3). The regression equations describing these relationships are given in Tables 2 and 4. The mean relative measurements of different body characters expressed as percent of total length along with their range and standard deviation are plotted in Fig. 2 (riverine fishes) and Fig. 4 (Chau Tal fishes).

The mean standard length, mean head length and mean body length of the fishes of river Kali were 82.73%, 16.61% and 65.79% of the total length respectively, while the mean lengths of these characters in case of Chau Tal fishes were 84.71%, 14.95% and 66.11% respectively. The head length and standard length of the populations (river and Chau Tal) are significantly different from the body length (Tables 2 and 4).

In case of depth measurements it was found that the depths at caudal peduncles of fishes from two environments were significantly different (Tables 2 and 4). Body depth at the pectoral fin base also varied in fishes from the two environments. Other measurements of the body did not show any significant variations (Tables 2 and 4).

DISCUSSION

In *Labeo bata* it was found that in fishes above 190 mm, the regression lines of different body measurements on total lengths were almost linear, indicating that the growth of the fish above 190 mm length was isometric. However, such linear relationships between various body measurements and total lengths were not observed by some workers (Godsil, 1948 and Marr, 1955).

They reported that the ratio between various body parts with increasing length at different stages of life may not be having constant relative growth. The fishes of pond increased in length more rapidly than in the depth while the fishes of rivers increased in depth more rapidly than the length. This was further confirmed by analysing the length:weight data of the same fish (Chapter II). None of the body characters showed any difference between the sexes of L. bata in any of the two environments. This shows that in both the sexes the relative growth of the body parts was constant. However, Pritchard (1931) and Tandon (1961) reported different ratios between various body parts and total length of males and females. A remarkable stability of different morphometric characters was found by Khan (1972) in L. rohita which were collected from different environments and belonged to different age groups.

The significant difference in some morphometric characters between river and pond fishes, strongly suggests that these fishes belong to two different independent stocks. Such variations in the morphometric characters of the fishes of two populations are due to modificational effects of the environment or due to genetic effect (Krumholz and Cavanah, 1968). The fishes of pond adapted from the very beginning to confined water, while the riverine fishes enjoyed a wide distribution . Another reason for the differences which can be given is that most of the fishes stocked in pond Chau Tal were induced spawned while the fishes of rivers were obviously naturally spawned. Thus the differences between the two populations of L. bata may be related to these two factors as well.

SUMMARY

The samples were collected from the river Kali and a pond Chau Tal for the morphometric studies. The characters selected for the study were total length, standard length, head length, body length, depth at pectoral fin base, depth at dorsal fin base and depth of caudal peduncle. The regressions of different body measurements on total length were carried out and a linear relationship was noted in the fishes of both the environments. The various body proportions expressed as percent of total length revealed that depth of caudal peduncle, depth at dorsal fin base and head length were more significantly different between the fishes of pond and rivers than other characters. The covariance analysis revealed no significant difference between the two sexes.

Fig. 1. Regressions of different body measurements on total length of L. bata (riverine fishes).

Fig. 2. Different body measurements expressed as percentage of total length (riverine fishes).

(The central vertical lines represents the mean, horizontal line range, box of greater vertical width ± twice the standard error and box of smaller vertical width half the standard deviation).

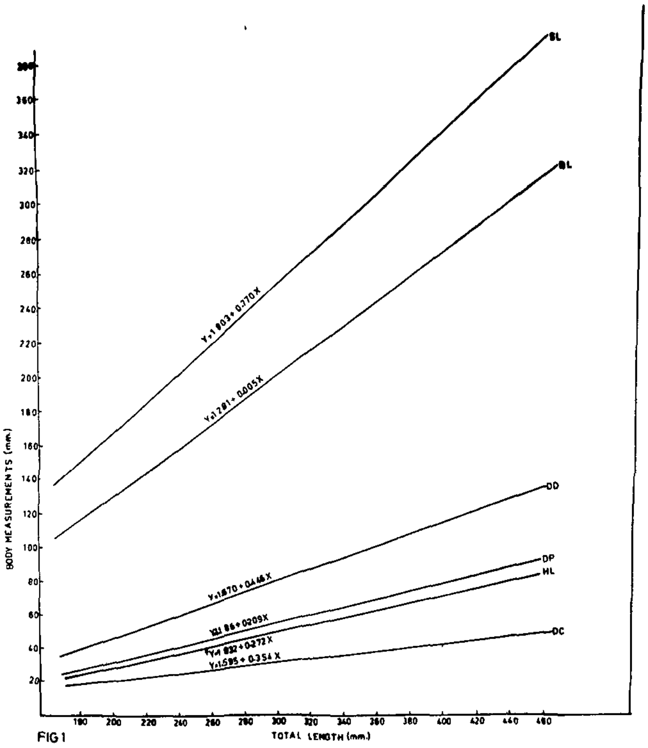

BODY MEASUREMENTS (mm.)
TOTAL LENGTH (mm.)
BL
BL
DD
DP
HL
DC
Y=1.903+0.770X
Y=1.595+0.354X

FIG 1

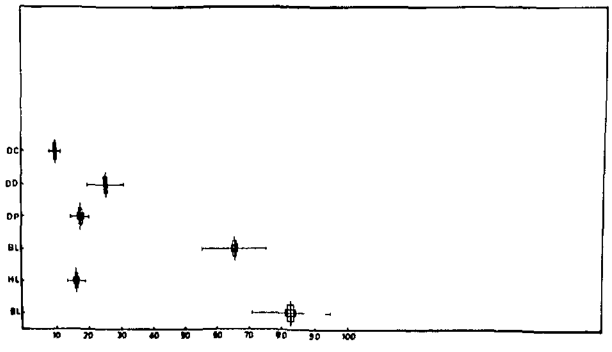
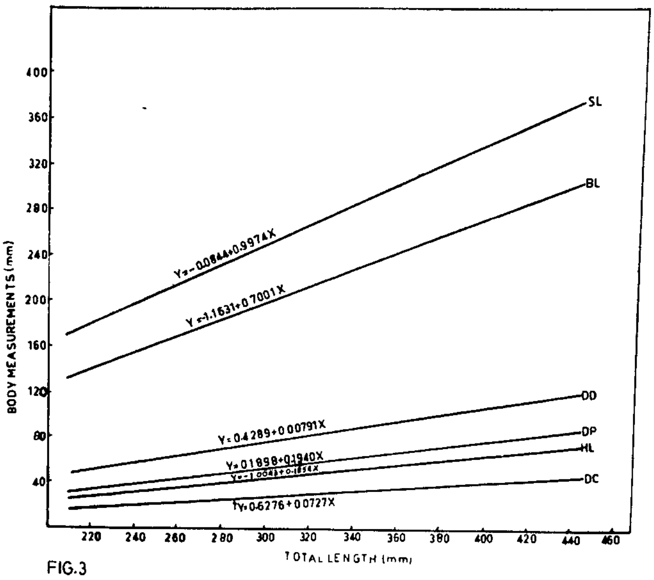

DC
DD
DP
BL
HL
BL
PERCENTAGE OF TOTAL LENGTH

FIG2

Fig. 3. Regressions of different body measurements on total length of L. bata (Chau Tal fishes).

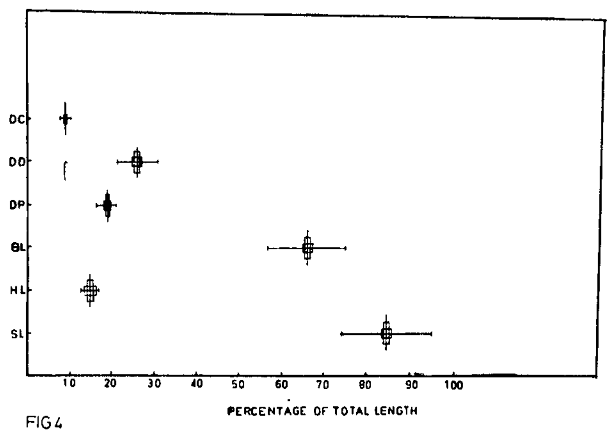
Fig. 4. Different body measurements expressed as percentage of total length (Chau Tal fishes).

(The central vertical lines represents the mean, horizontal line range, box of greater vertical width $\pm$ twice the standard error and box of smaller vertical width half the standard deviation).



BODY MEASUREMENTS (mm)
TOTAL LENGTH (mm)
SL
BL
DD
DP
HL
DC
Y=-0.0844+0.9974X
Y=-1.1631+0.7001X
Y=0.4289+0.00791X
Y=0.1898+0.1940X
Y=0.6276+0.0727X

FIG.3



DC
DD
DP
BL
HL
SL
PERCENTAGE OF TOTAL LENGTH

FIG 4

TABLE 1

STATISTICS OF REGRESSION OF DIFFERENT BODY MEASUREMENTS ON TOTAL LENGTH OF *L. BATA*

(RIVERINE FISHES)

Character	Regression coefficient	S.S. due to regression	Residual S.S.	D.F.
	MALE			
Standard length	0.793	708.287	52.316	120
Head length	0.101	274.271	19.821	120
Body length	0.738	598.233	16.237	120
Depth through pectoral fin base	0.144	825.154	64.550	120
Depth through dorsal fin base	0.603	794.169	33.565	120
Depth of the caudal peduncle	0.114	657.982	10.262	120
	FEMALE			
Standard length	0.730	4924.975	56.451	178
Head length	0.193	708.134	18.918	178
Body length	0.663	775.966	22.701	178
Depth through pectoral fin base	0.206	567.811	18.862	178
Depth through dorsal fin base	0.289	531.505	17.443	178
Depth of the caudal peduncle	0.122	656.625	10.767	178
	COMBINED			
Standard length	0.770	1273.931	24.254	298
Head length	0.272	879.789	24.293	298
Body length	0.005	220.073	24.359	298
Depth through pectoral fin base	0.209	68.319	24.375	298
Depth through dorsal fin base	0.446	91.784	27.493	298
Depth of the caudal peduncle	0.354	190.820	24.191	298

TABLE 2

EQUATIONS OF THE REGRESSION OF DIFFERENT BODY MEASUREMENTS ON TOTAL LENGTH OF *LABEO BATA*

(RIVERINE FISHES)

Character	Mean total length (cm) $\bar{x}$	Mean length of body measurements (cm) $\bar{y}$	Regression equation $y = a + b x$	Percent of total length
		MALE		
Standard length	32.5	26.9	$y = 1.094 + 0.793 x$	82.76
Head length	32.5	5.4	$y = 2.162 + 0.101 x$	16.61
Body length	32.5	21.3	$y = -2.721 + 0.738 x$	65.53
Depth through pectoral fin base	32.5	5.9	$y = 1.268 + 0.144 x$	18.15
Depth through dorsal fin base	32.5	8.1	$y = 1.679 + 0.603 x$	24.92
Depth of the caudal peduncle	32.5	3.4	$y = -0.245 + 0.114 x$	10.46
		FEMALE		
Standard length	28.9	24.0	$y = 2.927 + 0.730 x$	83.04
Head length	28.9	4.9	$y = -0.627 + 0.193 x$	16.95
Body length	28.9	19.1	$y = -0.030 + 0.662 x$	66.08
Depth through pectoral fin base	28.9	5.1	$y = -0.828 + 0.206 x$	17.64
Depth through dorsal fin base	28.9	7.7	$y = -0.663 + 0.289 x$	26.64
Depth of the caudal peduncle	28.9	3.0	$y = -0.511 + 0.122 x$	10.38
		COMBINED		
Standard length	30.7	25.4	$y = 1.803 + 0.770 x$	82.73
Head length	30.7	5.1	$y = 2.832 + 0.272 x$	16.61
Body length	30.7	20.2	$y = 1.281 + 0.005 x$	65.79
Depth through pectoral fin base	30.7	5.5	$y = 1.186 + 0.209 x$	17.91
Depth through dorsal fin base	30.7	7.9	$y = 1.670 + 0.446 x$	25.73
Depth of the caudal peduncle	30.7	3.2	$y = 1.595 + 0.354 x$	10.42

TABLE 3

STATISTICS OF REGRESSION OF DIFFERENT BODY MEASUREMENTS ON TOTAL LENGTH OF L. BATA

(CHAU TAL)

Character	Regression coefficient (b)	S.S. due to regression	Residual S.S.	D.F.
	(Combined fishes)			
Standard length	0.9974	1835.4402	580.8552	100
Head length	0.1854	1224.9411	29.6439	100
Body length	0.7001	1116.3544	13.7730	100
Depth through pectoral fin base	0.1940	4137.6697	401.2211	100
Depth through dorsal fin base	0.0791	4410.9051	315.6320	100
Depth of the caudal fin	0.0727	660.0695	59.4515	100

D.F. = Degrees of freedom S.S. = Sum of squares

TABLE 4

EQUATIONS OF THE REGRESSION OF DIFFERENT BODY MEASUREMENTS ON TOTAL LENGTH OF <u>L. BATA</u>

(CHAU TAL)

Character	Mean total length (cm) ($\bar{x}$)	Mean length of body measurement (cm) ($\bar{y}$)	Regression equation $y = a + b x$	Percent of total length
		(Combined fishes)		
Standard length	30.1	25.5	$y = -0.0844 + 0.9974\ x$	84.71
Head length	30.1	4.5	$y = -1.0043 + 0.1854\ x$	14.95
Body length	30.1	19.9	$y = -1.1631 + 0.7001\ x$	66.11
Depth through pectoral fin base	30.1	5.8	$y = 0.1898 + 0.1940\ x$	19.26
Depth through dorsal fin base	30.1	7.9	$y = 0.4289 + 0.0791\ x$	26.24
Depth of the caudal peduncle	30.1	2.7	$y = 0.6276 + 0.0727\ x$	8.97

CHAPTER II

LENGTH-WEIGHT RELATIONSHIPS

INTRODUCTION

The application of length-weight relationship in fishery biology, solves various problems concerning with the life history of fishes. Besides providing a mathematical relationship between length and weight of fish as a means of interconversion, such relationship also yields information on general well being of the fish, variations in growth, size at first maturity, gonad development and breeding season.

Length-weight relationships of many Indian major carps have been reported. Khan and Hussain (1941) made a preliminary study on the length-weight relationship of *Labeo rohita* and *Cirrhina mrigala* and Jhingran (1952) gave a general account on length-weight relationship of major carps. Natarajan and Jhingran (1963) have studied in detail, the length-weight relationship of *Catla catla* and Khan (1972) made a detailed investigation on the length-weight relationship of *L. rohita* and *C. mrigala* from North India.

The present study reports the length-weight relationship of *L. bata* from the river Kali.

MATERIALS AND METHODS

Samples for length-weight studies were collected from the river Kali using cast nets. A total of 324 fish belonging to all size classes were analysed. Total length of each fish was recorded to the nearest mm and weighed upto 0.1 g. The fish were sexed and their state of maturity assessed according to the scheme followed by Qayyum and Qasim (1964).

The length-weight data was analysed according to LeCren (1951).

Fishes were analysed into several groups, namely, juveniles, males, females, gutted fishes and fishes of five different maturity stages and treated separately. Values of length and weight data were plotted on a double logarithmic paper and the regression of log length was calculated by the least squares method.

The equation $\log W = \log a + n \log L$ was calculated separately for each group and a straight line was fitted to the scatter diagram. The weight of fish at each length interval was calculated by the equation and a length-weight curve was plotted.

To establish differences, if any, in the regression of log weight on log length of the fish of different groups, covariance analysis was employed (Mather, 1964).

RESULTS

A summary of the regression analysis of length-weight relationship along with the test of significance is given in

Table 5. Table 6 shows the analysis of variance for the data of Table 5. 'n' values were found to differ from one group to other and ranged from 2.5513 (gutted females) to 3.2026 (ripe females) and 2.6898 (gutted males) to 3.3109 (ripe males). The value of 'n' was highest (3.3832) in juveniles and lowest in females (3.2026). It was significant to note that 'n' values calculated at 95% confidence intervals for male, female and juvenile were always higher than 3 (Table 7).

The length-weight relationships of males, females and juveniles are presented in Table 7 and Fig. 5. Figure 6 shows the length-weight relationship of combined fishes. The smooth curve represents the calculated weight at each length interval while the straight line represents the calculated regression line. Average weight at different length intervals are tabulated in Table 8. It may be seen that the increase in weight in relation to length was not well marked upto 150 mm but was well appreciable above 200 mm. Females were found to be lighter than males upto the length of 250 mm while the males were lighter than females at higher lengths and the length-weight curves of the two sexes intersected at a point between 250 mm and 270 mm.

DISCUSSION

For L. bata the values of slope 'n' were always found to be higher than 3 and significantly different. Hence the length-weight relationship did not follow the cube law strictly.

It is quite clear from the results that the weight of fishes increased more than the cube of the length. In other carps higher values of 'n' than 3 have also been reported. Natarajan and Jhingran (1963) observed a value of 3.2328 in case of <u>Catla catla</u> while Jhingran (1952) reported a value of 3.221 in <u>Cirrhina mrigala</u>. Chakrabarty and Singh (1963) also observed that the value of 'n' was considerably higher than 3 in <u>Cirrhina mrigala</u>. These authors have considered total length as a parameter in calculating the value of 'n' while Jhingran (1952) in studying the length-weight relationship of major carps, used furcal length as a parameter and calculated the value of 'n' as 3.15172, 3.02483 and 3.01460 in case of <u>C. mrigala</u>, <u>C. catla</u> and <u>L. rohita</u> respectively. His observation showed that the departure from 3 was least in case of <u>L. rohita</u> and was not significant. Khan (1972) also observed the value of 'n' as 3.0592 and 3.0520 in case of <u>L. rohita</u> and <u>C. mrigala</u> respectively. Recently, Ramamohana Rao and Hanumantha Rao (1972) observed the value of 'n' as 3.1858 in case of <u>Labeo calbasu</u> and Bhatnagar (1972) reported the value of 'n' in <u>Labeo fimbriatus</u> as 3.0802. These investigations show that the value of 'n' was always higher than 3 in case of carps. The present study also reveals a clear departure from 3.

Jhingran (1952) in <u>L. rohita</u> and Khan (1972) in <u>L. rohita</u> and <u>C. mrigala</u> found an interesting relationship between observed and calculated weight of the fishes. They found that the observed weight of the fish was lesser than the calculated weight of the fish. This case was found to be completely reversed in larger fishes and in these groups the observed weight was higher than the calculated weight. A similar case has been noted in L. bata when a comparison was made between observed and calculated weights in smaller and larger fishes.

In fish of different maturity stages 'n' values were found to be higher in ripe fishes and lower in spent fishes. This clearly shows that in the spawning season the weight of gonads increased considerably and so the total weight of adult fishes also increased. As soon as the fishes discharged their gonad products, suddenly the weight decreased which consequently affected the 'n'. Such changes in the value of 'n' reflect the extent of the spawning season of the fish.

Several workers have reported that females are heavier than males in smaller sized fishes while males are heavier than females in larger sized fishes (Olsen and Merriman, 1946; Natarajan and Jhingran, 1963 and Khan, 1972). In the present case also the length-weight curve of males lies above the length-weight curve of female upto the length of 250 mm and beneath the length-weight curve of females thereafter. The point of intersection is between 250-270 mm. Olsen and Merriman (1946) gave a detailed account on this aspect and stated that this point of intersect represents the size at first maturity of the fish. Natarajan and Jhingran (1963) came to a similar conclusion in *C. catla* and observed that the two curves intersected at a point between 500 mm and 650 mm which is also the size range at which most of the fish attain maturity.

Chakrabarty and Singh (1963) reported a reverse phenomenon in the case of *C. mrigala*. He found that males are heavier in smaller fishes and females in larger fishes. Khan (1972) found that the length-weight curves of males and females of *L. rohita* intersected at a point between 500 and 600 mm. In studying the maturation and spawning of *L. rohita* in a separate observation, he noticed that most of the fishes of both sexes mature at a length range of 500 and 600 mm. In *L. bata* the length-weight curves of males and females intersected between 250 mm and 270 mm, the range of size at which both sexes attain first sexual maturity.

SUMMARY

The study of length-weight relationship of *Labeo bata* revealed that this fish did not follow the cube law strictly and the weight increase at a rate more than the cube of the length. No significant difference was noticed in the value of 'n' by the analysis of covariance between the fishes of different size, sex and maturity stages in a population. The equations for length-weight relationship are $W = 0.2821 \times 10^{-5} L^{3.3109}$ for the male, $W = 0.3388 \times 10^{-5} L^{3.2026}$ for the female,

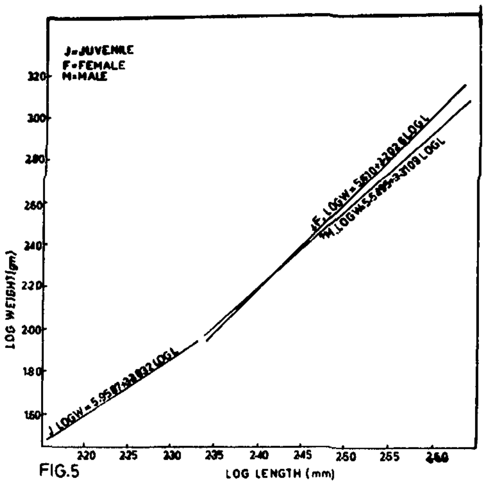
$W = 0.2588 \times 10^{-5} L^{3.3832}$ for juvenile and $W = 0.4893 \times 10^{-5} L^{3.1667}$ for the combined fishes.

The males were slightly heavier than females at smaller sizes and females were heavier than males at larger sizes and the two length-weight curves intersected at a point between 250 mm and 270 mm. This point of intersection represents the size at first maturity of the fish.

Fig. 5. The length-weight relationships of males, females and juveniles of *L. bata*.

Fig. 6. The length-weight relationship of combined *L. bata*.

(The straight line represents the calculated regression line of log weight on log length and the smooth curve represents the calculated weight).


J=JUVENILE
F=FEMALE
M=MALE
LOG WEIGHT (gm)
LOG LENGTH (mm)
FIG.5

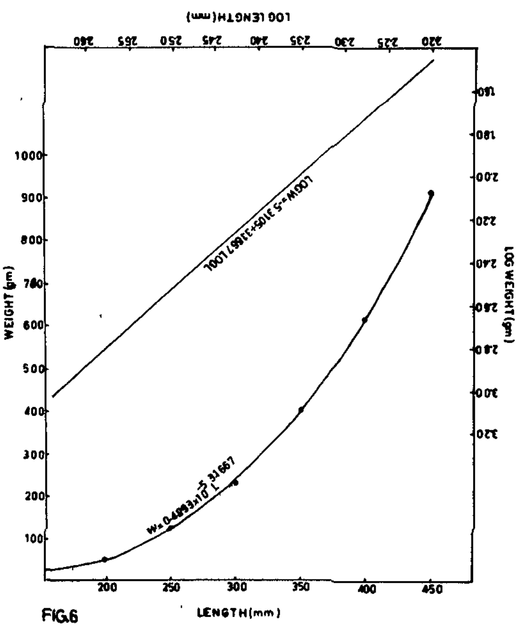

LOG LENGTH (mm)
WEIGHT (gm)
LOG WEIGHT (gm)
LENGTH (mm)
FIG.6

TABLE 5

STATISTICS OF REGRESSION OF LOG WEIGHT ON LOG LENGTH OF <u>L. BATA</u>

Source	Regression coefficient 'b'	S.S. due to regression	Residual S.S.	D.F.	Correlation coefficient 'r'	Observed 'T'	5% t	Significance
Male	3.3109	27.2850	4.9937	132	0.1222	2.0414	1.960	S
Female	3.2026	23.3921	4.1746	170	0.1504	1.9831	1.960	S
Juvenile	3.3832	17.1886	4.2550	21	0.6507	3.8320	2.080	S
Maturity stage I Male	3.2753	2.7491	0.1299	39	0.9215	1.3215	2.023	NS
Maturity stage I Female	3.0929	0.6500	0.0375	46	0.1304	1.8821	2.015	NS
Maturity stage II Male	3.7982	0.4391	0.0221	8	0.4059	1.1750	2.306	NS
Maturity stage II Female	3.0720	0.3354	0.0299	12	0.3172	1.1092	2.179	NS
Maturity stage III Male	3.6966	0.9917	0.0383	38	0.1297	1.7956	2.025	NS
Maturity stage III Female	3.3116	0.6160	0.0564	35	0.9916	1.8910	2.031	NS
Maturity stage IV Male	3.4872	1.2234	0.0355	38	0.8292	1.0229	2.025	NS
Maturity stage IV Female	3.5928	1.2858	0.0197	60	0.1992	1.5607	2.000	NS
Maturity stage V Male	3.1772	0.6488	0.0517	4	0.7242	1.8187	3.747	NS
Maturity stage V Female	3.0316	0.2541	0.0072	12	0.9865	1.9952	2.179	NS
Total within different maturity stages	3.2989	24.0929	10.1476	313	-	-	-	-
		DIFFERENCE	0.0187	10				
Total between means of different maturity stages	3.3283	0.2707	0.0199	9	-	-	-	-
		TOTAL	10.1675	323	-	-	-	-
Combined (Male, Female, Juvenile)	3.1667	24.3636	10.1663	324	0.3407	6.5214	1.960	S
		DIFFERENCE	0.0012	1	-	-	-	-

S.S. = Sum of squares D.F. = Degrees of freedom N.S = Not significant S = Significant

TABLE - 6

ANALYSIS OF VARIANCE FOR DATA IN TABLE 5

Source	Sums of square	D.F.	Variance
Due to total regression	24.3636	1	24.3636
Between regression coefficient within different maturity stages	0.0187	10	0.0018
Difference between pooled within different maturity stages and means regression	0.0012	1	0.0012
Deviation of means from means regression	0.0199	9	0.0022
Residual	10.1663	313	-
Total	34.5697	324	-

TABLE 7

REGRESSION EQUATIONS OF WEIGHT ON LENGTH OF *LABEO DATA* AND THEIR TEST OF SIGNIFICANCE

SOURCE	REGRESSION COEFFICIENT 'b'	INTERCEPT 'a'	VARIANCE OF 'b'	S.D. OF 'b'	S.E. OF 'b'	95% CONFIDENCE LIMIT OF 'b'	S.E. OF 'a'	REGRESSION EQUATION	PARABOLIC EQUATION
MALE	3.3109	-5.5495	0.0518	0.2275	0.0198	3.2721-3.3497	0.00485	$\text{Log } W = -5.5495 + 3.3109 \text{ Log } L$	$W = 0.2821 \times 10^{-5} L^{3.3109}$
FEMALE	3.2026	-5.4610	0.0353	0.1880	0.0144	3.1743-3.2308	0.00455	$\text{Log } W = -5.4610 + 3.2026 \text{ Log } L$	$W = 0.3388 \times 10^{-5} L^{3.2026}$
JUVENILE	3.3832	-5.9587	0.0808	2.2842	0.0605	3.2646-3.5017	0.01283	$\text{Log } W = -5.9587 + 3.3832 \text{ Log } L$	$W = 0.2588 \times 10^{-5} L^{3.3832}$
COMBINED	3.1667	-5.3105	0.0443	0.2115	0.0117	3.1437-3.1896	0.00321	$\text{Log } W = -5.3105 + 3.1667 \text{ Log } L$	$W = 0.4893 \times 10^{-5} L^{3.1667}$

S.D. STANDARD DEVIATION S.E. STANDARD ERROR

TABLE - 8

CALCULATED WEIGHT OF *L. BATA* AT DIFFERENT LENGTH INTERVALS

Total length (in mm)	Body weight (in gms)
150	25.3
200	50.4
250	133.4
300	229.5
350	410.1
400	625.3
450	914.1

CHAPTER III

RELATIVE CONDITION FACTOR

INTRODUCTION

The condition of fish is subjected to a great number of variations depending upon the various factors in the nutritional and biological cycles of the species. Depending upon the equations used in length-weight relationship, the condition factor of fishes has been calculated in two ways. The first method is based on the cube law and the second is based on the exponential equation ($W = aL^n$). In the former case, the condition (K) is calculated by the equation $K = W/cL^3$, where W and L are the weight and length of the fish respectively and 'c' is constant. If the specific gravity of fish is unity and the value of 'c' is 1, then $K = W/L^3$. The value of 'K' is generally multiplied by 100 to obtain the value of 'K' into a round figure as $K = 100\ W/L^3$ (Hile, 1936).

In the later case, however, the relative condition (Kn) is calculated by the formula $Kn = W/aL^n$, where aL^n shows the calculated weight (from the regression equation) and W is observed weight. This equation may also be written as observed weight/ calculated weight (W/WO) (LeCren, 1951). The value of 'Kn' fluctuates around one and departures from 1 represent the deviation from the regression of weight on length as proportional part of the standard 1.0. This deviation represents all variations in weight not associated with length, for example genetic variation, variation associated with food supply, sexual condition and parasitism (Blackburn, 1960). Blackburn (1960) emphasized that these variations can not be evaluated with the help of condition factor (K) unless 'n' is actually 3, which is rarely the case.

To obtain the maximum information regarding the life history of L. bata (Ham.), relative condition factor was calculated for the two sexes separately at different maturity stages and in different months.

MATERIALS AND METHODS

The data used for the present investigation comprised of 324 specimens (134 males and 188 females) collected from the river Kali using cast nets and drag nets.

The method as evolved by LeCren (1951) in studying the condition of perch, Perca fluviatalis, was followed here for the calculation of relative condition factor (Kn) of L. bata as $Kn = W/aL^n$. The 'Kn' values obtained were then placed into several groups according to size, sex, maturity and season.

In order to facilitate a direct comparison of gonado-somatic index (gonad weight expressed as percentage of body weight) and relative condition factor, between different groups of fish, the average values of 'Kn' obtained were converted as percentage of the maximum and were plotted for each sex separately. For each month the percentage gonad weight was substracted from the average value of 'Kn' for that month. These values are termed as condition minus gonad and have been plotted in the same figure. To determine whether the weight of gut has any influence on seasonal changes on 'Kn' of the fish, the gastro-somatic indices (gut weight expressed as percentage of body weight) of the fishes of both sex separately, is substracted from the value of condition minus gonad and termed as condition minus gonad and gut. This value has also been plotted in the same figure.

RESULTS

At the size class 210 mm in females and 230 mm in males, a sudden increase in the value of 'Kn' was observed. This was followed by alternate decrease and increase in the 'Kn' values upto the length of 450 mm (Table 9, Fig. 7).

The gonado-somatic indices of L. bata showed seasonal variation in both the sexes. It started increasing from March and reached to the maximum level in May in case of males (Table 10, Fig. 8) and in June in case of females (Table 10, Fig. 9). The gastro-somatic indices dropped suddenly in July and August. From September to January it almost remained constant. The seasonal changes were found to be more pronounced in females than in the males (Fig. 10).

Seasonal fluctuations in relative condition can be seen in Table 11 and Fig. 10. High values were recorded in the months of April, May and June when the fish contained fully ripe gonads. Just after the spawning, relative condition factor declined (July and August). Higher values were also recorded during December 1972, October 1973 and February 1974 (Fig. 11).

From April to June the condition minus gonads of females decreased considerably and the condition with gonads increased during the same period. The decreasing condition with gonads during July and August was very clear while the condition minus gonads did not show any significant decrease. During rest of the months, there was no significant difference between condition with gonads and condition minus gonads. Similar pattern was observed for males. Gastro-somatic index in females was found to decrease considerably during April to July. In other months gastro-somatic indices of both the sexes were found to be high (Table 10, Figs. 8 and 9).

The 'Kn' value fluctuated considerably in fish of different maturity stages. High values were obtained for immature fishes (170 mm). A peak was noticed at IV or ripe stage, which was followed by a sharp decline at V or spent stage in both the sexes (Table 12, Fig. 11).

DISCUSSION

Fluctuations in relative condition with length of the fish are quite apparent. In juveniles, the values were high (170 mm), dropped in the next size class and again increased at the size of 230 mm. High values in juveniles appear to be due to high rate of feeding while high values at 210 and 230 mm are most probably due to attainment of first sexual maturity. Similar observations have been reported in L. rohita and C. mrigala (Khan, 1972).

Pantulu (1961) suggested that this increase and decrease in the values of 'Kn' during different length groups of both the sexes can be related to the number of spawnings during the life span of the fish. In case of L. bata there were 3 peaks and 3 valleys upto the length of 450 mm which showed that this fish spawned three times before reaching this length. In Labeo calbasu upto the length of 570 mm 3 peaks were reported which revealed that this fish also spawned thrice before reaching to this length (Ramamohana Rao et al. 1972) while Khan (1972) reported 5 peaks in case of L. rohita upto the length of 900 mm.

The monthly fluctuations in 'Kn' values are known to be influenced by two factors. The majority of authors reported that fluctuations in condition are closely related to the sexual cycle of the fish and this increase and decrease in 'Kn' is due to increase and decrease in weight of gonads before and after the spawning (LeCren, 1951; Pillay, 1953; Sarojini, 1957 and Pantulu, 1961). However, other workers have suggested that monthly fluctuations in the condition factor are more closely related to the feeding rhythm than to the reproductive cycle and is independent of it (Hile, 1948; Qasim, 1957; Bal and Jones, 1960; Blackburn, 1960 and Bhatt, 1971).

In L. bata the seasonal changes in 'Kn' values showed that both sexes attain peak condition in June. This rise in 'Kn' value from April to June corresponds with the period of maturation of gonads as it is closely associated with rise in gonado-somatic indices during these months. The abrupt fall in condition during July and August may be attributed to the spent condition of the fish. Similar trend was noted in case of Labeo rohita and Cirrhina mrigala by Khan (1972). Slight increase in condition of L. bata during October to February with a peak in February may be due to active feeding during these months when plankton, the main food of the species, is abundant.

During the months of April to June the increase in condition with gonads was due to increasing gonads weight while the continued decrease in condition minus gonad indicated that certain amount of growth potential was sacrificed for the gonad building and the gonad weight increased probably at the expense of the rest of the body. This sacrifice was more pronounced in females than in the males as the ovary weight increases enormously as compared to testes weight.

SUMMARY

The relative condition factor 'Kn' of L. bata was studied in different size groups, different maturity stages and during different months. The 'Kn' value was high in smaller size group. The value decreased upto the length of 190 mm of both sexes and thereafter, a sudden increase was followed by a decrease in subsequent size group. The fishes were found to attain peak condition 3 times upto the length group of 450 mm.

Studies on the monthly fluctuations in condition indicated that the condition is generally started to increase in March and reached to maximum during June and then decreased suddenly during July and August. While condition with gonads was found to increase during March to June, the condition minus gonads continued to decrease.

Fig. 7. Mean 'Kn' values at different size groups of L. bata.

Fig. 8. Seasonal fluctuations in 'Condition with gonad', 'Condition minus gonad' and 'Condition minus gonad plus gut' of L. bata (males).

Fig. 9. Seasonal fluctuations in 'Condition with gonad', 'Condition minus gonad' and 'Condition minus gonad plus gut' of L. bata. (females).

(The upper curves represent the 'condition with gonad', the middle 'condition minus gonad' and the lower 'condition minus gonad plus gut'. The area enclosed by uppper and middle curves represent the gonado-somatic index and by the middle and lower curves represents the gastro-somatic index).

Fig. 10. Monthly variations in mean 'Kn' values of L. bata.

Fig. 11. Mean 'Kn' values of L. bata at different maturity stages.

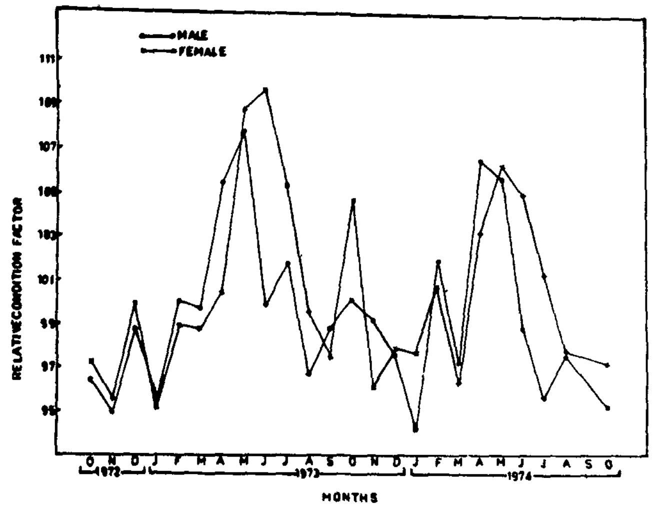


FIG.10

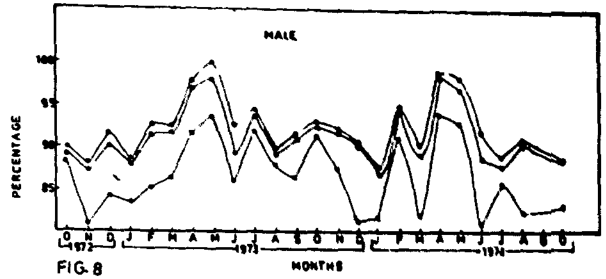


FIG. 8

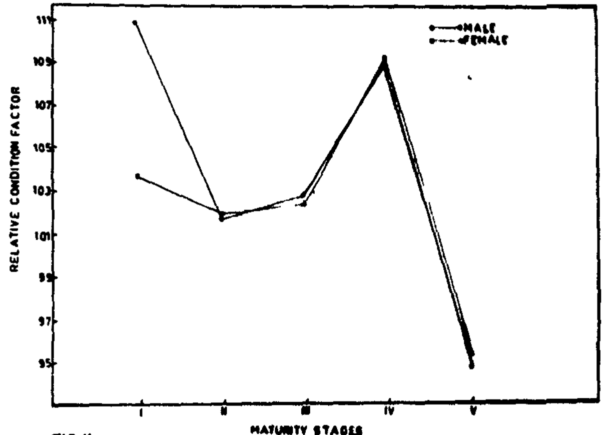


FIG.11

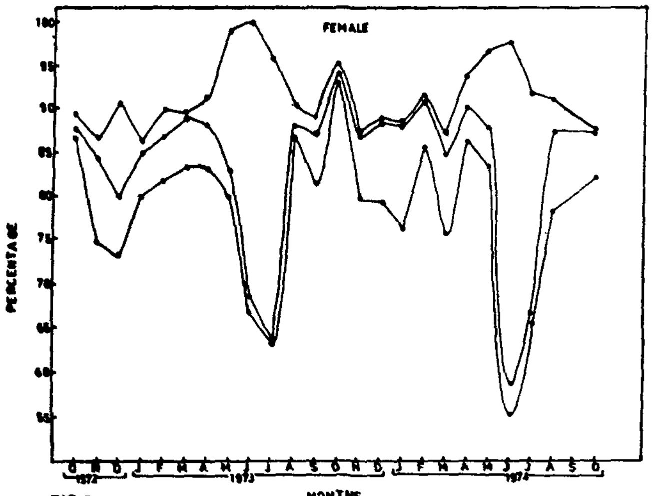


FIG.9

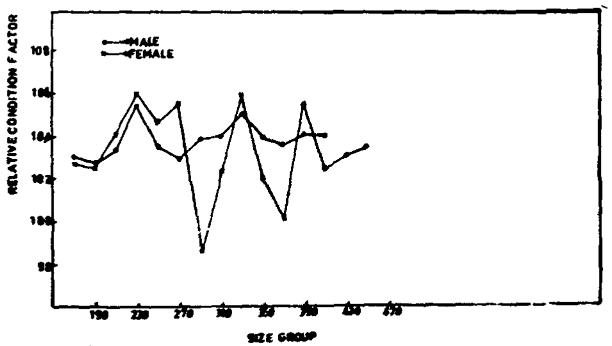


FIG.7

TABLE - 9

MEAN 'Kn' VALUES OF L. BATA AT DIFFERENT SIZE GROUPS

Size group	Mean 'Kn'	
	Male	Female
150 - 170	103.0	102.7
171 - 190	102.7	102.5
191 - 210	103.3	104.0
211 - 230	105.4	105.9
231 - 250	103.4	104.5
251 - 270	102.9	105.5
271 - 290	103.8	98.5
291 - 310	103.9	102.2
311 - 330	104.9	105.9
331 - 350	103.8	101.9
351 - 370	103.5	100.0
371 - 390	104.0	105.4
391 - 410	103.9	102.3
411 - 430	-	103.0
431 - 451	-	103.4

TABLE 10

CONDITION WITH GONAD, WITHOUT GONAD AND WITHOUT GONAD AND GUT OF L. BATA

Month	MALE Condition (% of max.)	MALE Gonado-somatic index	MALE Condition (minus gonad)	MALE Gastro-somatic index	MALE Condition (minus gonad and gut)	FEMALE Condition (% of max.)	FEMALE Gonado-somatic index	FEMALE Condition (minus gonad)	FEMALE Gastro-somatic index	FEMALE Condition (minus gonad and gut)
Oct. 1972	90.00	0.52	39.48	1.15	88.33	88.53	0.71	87.82	1.17	86.65
Nov.	88.00	0.56	87.44	6.53	80.91	86.98	2.47	84.51	9.77	74.74
Dec.	91.57	1.34	90.23	6.10	84.13	90.99	10.71	80.28	6.64	73.64
Jan. 1973	88.51	0.49	88.02	4.51	83.41	86.62	1.59	85.03	4.94	80.09
Feb.	92.68	1.24	91.44	6.36	85.08	90.08	2.91	87.17	5.18	81.99
March	92.41	0.62	91.79	5.57	86.22	39.00	1.44	88.46	5.29	83.17
April	97.78	0.81	96.97	5.53	91.44	91.44	2.56	88.88	4.55	84.33
May	100.00	1.97	98.03	4.22	93.81	99.19	15.99	83.00	3.12	80.08
June	92.58	3.28	89.30	3.37	85.93	100.00	31.30	68.70	2.14	66.56
July	94.44	0.62	93.83	1.90	91.92	96.00	32.00	64.00	0.96	63.04
Aug.	89.63	0.40	89.23	1.52	87.71	90.72	2.45	88.27	1.06	87.21
Sept.	91.57	0.43	91.14	5.00	86.14	88.71	1.27	87.44	6.14	81.30
Oct.	92.87	0.55	92.32	1.18	91.14	95.54	0.63	94.91	1.12	93.79
Nov.	91.94	0.28	91.66	4.62	87.05	87.53	0.33	87.20	7.38	79.82
Dec.	90.46	0.09	90.37	9.29	81.08	89.26	0.33	88.93	9.67	79.26
Jan. 1974	87.31	0.62	86.69	5.50	81.19	88.98	0.52	88.46	12.35	76.11
Feb.	94.61	0.07	94.56	3.62	90.94	91.90	0.54	91.37	5.51	85.86
March	90.18	1.21	88.97	7.35	81.62	87.71	2.70	85.01	9.48	75.53
April	98.99	1.07	97.92	4.49	93.43	94.18	3.75	90.43	3.85	86.58
May	98.15	1.45	96.70	4.14	92.56	97.00	8.99	88.01	4.19	83.82
June	91.66	3.14	88.52	8.12	80.40	95.72	37.16	58.56	3.51	55.05
July	88.78	1.45	87.33	2.22	85.11	92.35	25.62	66.73	1.39	65.34
Aug.	90.64	0.24	90.41	8.68	81.73	89.08	1.17	87.91	9.56	78.35
Sept.	-	-	-	-	-	-	-	-	-	-
Oct.	88.33	0.40	87.93	5.54	82.39	88.98	0.61	88.37	6.26	82.11

TABLE - 11

MONTHLY VARIATIONS IN MEAN 'Kn' VALUES OF *L. BATA*

MONTH	MALE	FEMALE
October, 1972	96.3	97.3
November	94.9	95.5
December	98.8	99.9
January, 1973	95.5	95.1
February	100.0	98.9
March	99.7	98.7
April	105.5	100.4
May	107.9	108.9
June	99.9	109.8
July	101.9	105.4
August	96.7	99.6
September	98.8	97.4
October	100.2	104.9
November	99.2	96.1
December	97.6	98.0
January, 1974	94.2	97.7
February	102.1	100.9
March	97.3	96.3
April	106.8	103.4
May	105.9	106.5
June	98.9	105.1
July	95.8	101.4
August	97.8	97.8
September	-	-
October	95.3	97.7

TABLE - 12

MEAN 'Kn' VALUES OF L. BATA AT DIFFERENT MATURITY STAGES

Maturity stages	Mean 'Kn'		
	Juvenile	Male	Female
0	103.1	-	-
I	-	104.1	103.6
II	-	101.7	101.8
III	-	102.7	102.2
IV	-	108.9	109.1
V	-	94.6	95.2

CHAPTER IV

AGE AND GROWTH

INTRODUCTION

The significance of age and growth of a fish is essential for a fishery biologist in solving various problems of its life history and the study has led to the accumulation of considerable information on this subject, particularly from the temperate regions. There have also been attempts of varying degrees of success in the determination of age of tropical and subtropical fishes of Indian waters, like, Hornell and Naidu (1924); Devanesan (1943); Nair (1949) and Chidambaram (1950) on *Sardinella longiceps*; Rao (1934) on *Therapon jarbua*; Hora and Nair (1940); Chacko *et al*. (1948); Chacko and Krishnamurty (1950); Jones and Menon (1951) and Raj (1951) on *Hilsa ilisha* and Chidambaram and Krishnamurty (1951) on *Rastrelliger kanagurta* from the marine environments. In these studies either the scale (Seshappa and Bhimachar, 1951, 1954; Pillay, 1954; Jhingran, 1957, 1959; Sarojini, 1957; Natarajan and Jhingran, 1963; Krishnakutty, 1968; Thakur, 1968; Kamal, 1969; Khan and Siddiqui, 1973 and Rangaswamy, 1973) or opercle (Qasim and Bhatt, 1968) or spine (Pantulu, 1961 and 1963) has been used for age determination.

From freshwaters the age and growth studies based on the interpretation of annual marks on scales have been successfully made on *Cirrhina mrigala* (Jhingran, 1957, 1959; Kamal, 1969) on *Catla catla* (Natarajan and Jhingran, 1963) and on *Labeo rohita*

(Khan and Siddiqui, 1973).

Age and growth of _Labeo bata_ has not been attempted so far and nothing could be said about its age, life span and growth rate. The present investigation deals with various aspects related to age and growth of the fish, like, age-length relationship, maximum size and age, annual and seasonal growth rate.

MATERIALS AND METHODS

The samples for the present investigation comprised of specimens collected from the river Kali during the period from October 1972 to October 1974. Total length was measured upto nearest mm, from the tip of the snout to the longest fin ray of the lower lobe of caudal fin. The scale samples were taken uniformly from the region directly below the dorsal fin and above the lateral line. 10-12 scales were removed from each fish. The same technique was followed here for the study of scale as described by Khan and Siddiqui (1973) for _Labeo rohita_. To remove the mucous from the surface of scales, the scales were rubbed gently by the fingers and washed with water. The filmsy tissue and other extraneous matter attached to scale are removed by this treatment. The scales were then dried on a neat blotting paper and kept in separate envelopes.

The scales were read with the help of a magnifying glass against narrow light source. The marginal rings and rings of small scales were studied with the help of a binocular. Ages were determined by counting the number of completed annuli. The regenerated scales were rejected. Fishes were classified under the 'age groups': those which have completed the age of the number mentioned after the age group while 'year class' represents the growing season of the fish. For example Age group II indicates the fishes which have completed its two years of age and possess two complete annuli while the 2nd year class represents the second growing season of the fish which has only one completed annulus.

The scale envelopes were mixed together for the determination of age and from the whole lot, envelopes were picked randomly one by one. Annuli were counted from each scale and noted on a separate sheet of a paper against the number of the envelope. At least 4 or 5 scales were read from each envelope. The whole lot of the envelopes were again mixed and the same procedure was repeated; ages were again determined irrespective of the previous diagnosis and if both the observations tallied, the age of the fish was considered final, otherwise, scales were read for a third time and if consistent interpretation was impossible, these scales were discarded. The percentage of scales with marginal rings during different months was also calculated to study the probable period of ring formation.

A paper ruler of millimeter graph paper was used to measure the length of the scale. The zero of the ruler was placed at the centre of the focus and along the most anterior median line in the anterior field. The ruler was then marked at each annulus and at the total length of the scale. The details about the length of the fish and month of the capture were noted on the reverse side of the ruler. Separate ruler was used for each scale.

The relationship between body length and scale radius was worked out by regression analysis (Least squares method). Length attained by the fish at the time of each annulus formation was back calculated for each specimen, separately, using the direct proportion formula (Lee, 1920) as

$$L_1 = \frac{L \times S_1}{S}$$

where 'L_1' is length of the fish at the time of annulus formation, 'L' is length of fish at the time of capture, 'S' is the length of scale from the focus to the anterior apex of the scale or scale radius, and 'S_1' is the distance between the focus and each annulus of scale.

The mean monthly lengths of the fishes were determined separately for each age group as revealed by the number of annuli on the scale. The specific growth 'G' of the fishes was calculated separately for each age group and size group by the following formula:

$$G = \frac{\text{Log}_e L_2 - \text{Log}_e L_1}{(T_2 - T_1)} \times 100 \quad \text{(Bal and Jones, 1960)}$$

Where 'L_2' and 'L_1' were the lengths of the fish at the times 'T_2' and 'T_1' respectively. 'L_1' and 'L_2' were the lengths at the beginning and at the end of each year of life. Thus $T_2 - T_1$ is one and 'G' (instantaneous growth rate) is expressed as percentage per annum.

Von Bertalanffy growth equation was fitted to length at age data as described by Beverton and Holt (1957).

RESULTS

Description of scale:

The scale of L. bata is a typical cycloid scale having focus near the centre of the scale. The centre is surrounded by numerous more or less concentric striations known as ridges or annuli. The annuli are continuous and homogenous, and provide the sculpturing which is interpreted in age determination. The circuli increase in height during the process of calcification. Radii represent the lines of flexibility in the scale. The anterior part of the scales are buried in dermal pockets and only the posterior portion projects from the pocket. The buried anterior part bears growth ridges which appear as rings on the surface of bony outer layer. Some of these ridges project a little way on to the posterior surface. The rings are formed successively as the scale grows in area with the growth of the fish.

Nature of true growth rings:

The annuli or true growth rings are characterized by light bands which are carved out spaces between circuli in the form of grooves extended to the posterior and lateral sides of the scale. These carved out grooves are preceded by comparatively thicker and narrower circuli. These circuli form a chain of isolated islet-like structure at the region of groove. Posteriorly and laterally, these rings are parallel to the general contour of the scale. In the annular region, circuli are broken, discontinuous and incomplete. A ring is considered annulus only when it is present in all the scales of the fish.

False rings:

Some times incomplete, irregular rings were found in the scale of L. bata. These accessary checks are known as false rings and they are not parallel to the general contour of the scale. Such type of scales are not having continuous groove on both, lower lateral and upper lateral halves of the scale. These grooves are in the form of folds and circuli crossing such folds show a continuity and regularity rather than the discontinuity and irregularity of the defined age ring. These rings generally occurred at irregular intervals and back calculation of lengths from such rings give absured results. False rings are not common in the scales of L. bata.

Abnormalities:

In L. bata 10-15% of the scales were found to be abnormal. The most common type of abnormality was asymmetrical regenerated scales (Latinucleate). The regenerated scale was having large fused focus, devoid of circuli, rough or granular in appearence or sometimes this type of scale showed a number of ridges like rings which in no way represented the annual marks. The relative size of regenerated centre depends on the size of the scale when regeneration began. The most symmetrical scales with no differences in size and shape and with least amount of abnormality were found just below the dorsal fin and above the lateral line. These scales were examined for age and growth studies.

Validity of scales as age and growth indicator:

The scales of Cirrhina mrigala, Catla catla and Labeo rohita showed clear zonations which could be used for studying the age and growth of these fishes (Jhingran, 1957, 1959; Natarajan and Jhingran, 1963; Kamal, 1969 and Khan and Siddiqui, 1973). These authors have also attempted to establish the annual nature of these rings and provided evidences in support of it. Labeo bata is closely related to these species, specially to

Labeo rohita and its scales have also been found to bear certain rings. The accuracy of scale method for age determination of *L. bata* was based on the following proportions (Van Oosten, 1929):

1. That the scales must remain constant in number and must retain their identity throughout the life.

2. That the scales must bear a constant proportional relationship with the length of the fish. In another way it can be also summarised that the growth of the scale must be proportional to the growth of the fish.

3. That the annulus must be formed yearly and at the same approximate time of each year.

In *L. bata* the number of scales along the lateral line were found to vary between 37-40 and within this range,this number was highly constant. The size and shape of the scale sculptured characterstics differed from one region to another but it almost remained constant throughout the life in one part and the highest degree of constancy in shape of the scales was found from the region just below the dorsal fin and above the lateral line.

Time of annulus formation:

The occurrence of marginal rings on the scale of *L. bata* were examined during different months of the year to determine the time of annulus formation. The new growth rings began to appear from March and thereafter all the fishes of first year-class (juveniles) were found to contain new growth rings. In adults (all year-classes except first year-class), examination of outer margin of the scales revealed that the new rings are formed between April and August, with a high frequency during June (Fig. 12). Besides, only one such ring appeared during the year.

The annuli were added systematically with the growth in length of the fish and this phenomenon is regarded as a preliminary evidence sustaining the validity of markings as annual (Plate 1-7). The constant appearence of new growth rings during one season of the year is also an evidence of their being true annual. The decreasing distance between the adjacent annuli as the fish grew was yet another evidence in support of the validity of scale method and progressively slow growth with increasing age (Plate 1-7). Similar evidences regarding the validity and occurrence of true annuli have been reported in Cirrhina mrigala (Jhingran, 1959 and Kamal, 1969), in Catla catla (Natarajan and Jhingran, 1963) and in Labeo rohita (Khan and Siddiqui, 1973). The length calculated by back calculation and imperical length and length determination by Von Bertalanffy growth equation at each age showed no significant difference.

Body length scale radius relationship:

Body length and scale radius relationship has also been used to prove the validity of scale method for age determination. In order to ascertain the relationship between the scale and the length of the fish, the individual measurements obtained were plotted on a graph paper which yielded a straight line relationship (Fig. 13). The regression equation Y = a+b X where'Y'= scale length (dependent variable) 'X' = Total length of the fish (Independent variable); 'a' is additive constant and 'b' is multiplying constant, was calculated for the regression of body length over scale length (scale radius) for further confirmation of validity of scales, as indication of age and growth. The results showed that the increase in length of the scale bear a constant ratio to the increase in length of the fish. The calculated values could be expressed as :

$$Y = -2.534 + 0.064 X$$

AGE AND GROWTH RATE

Age composition:

The length frequency distribution at each age group of *L. bata* as revealed by scale study is given in Table 14. The length frequency distribution of the sizes was based on the back calculations of lengths from the scales. The fishes of age groups I, II, III and IV comprised of a moderate number of specimens while fishes of age groups VI and VII were few in numbers. The samples did not obviously represent the actual composition but it showed an approximate age composition of the population.

CALCULATED ANNUAL GROWTH

Average calculated length at each annulus, absolute growth and growth increment:

The back calculated lengths from the fishes of different ages are represented in Table 15. The growth rate of males and females did not show any significant difference and therefore combined growth rate of males and females of L. bata has been investigated. L. bata was found to attain lengths of 131 mm, 194 mm, 236 mm, 277 mm, 314 mm, 341 mm and 364 mm at the age of 1, 2, 3, 4, 5, 6 and 7 years respectively. The first 4 years of life showed a rapid growth in length while the growth rate slowed down in subsequent age groups. A progressively declining growth rate with increasing age is also clearly visible from lower growth curve (growth increment curve) (Fig. 14). The maximum length recorded by the back calculation was 364 mm at the end of VII years of life.

Figure 15 shows the absolute growth curve of L. bata representing the weights at different ages. A sigmoid curve is obtained, showing a higher growth rate during early ages followed by a decreasing growth rate in older ages. The percentage of annual increment (relative growth) varied from 36.0% during the first year of life to 6.3% during the 7th year of life (Table 16).

Specific or instantaneous growth rate:

Table 16 and Fig. 16 show changes in the instantaneous growth rate (percentage length per year) with age. The growth rate was found to be 59.63% between the ages I and II and ultimately it dropped down to only 6.51% between ages VI and VII. The value of 'G' decreased gradually with increasing age of the fish.

Fitting of growth equation to length at age data:

Several equations have been evolved in order to describe the growth of the fish since many species of fishes have been found to follow different growth patterns. It was Walford (1946) who gave a method by which it was possible to arrive at the asymptotic growth of the fish ($L\infty$) and also the rate of growth increment (K). The lengths at ages 1, 2, 3, 4, 5 and 6 were plotted against lengths 2, 3, 4, 5, 6 and 7. A line of 'best fit' was then drawn. The ultimate length attained by *L. bata* was determined graphically at a point where the length at age 'n' equals the length at age n + 1. A line was drawn at

45° through zero point. The curve intersected this line and the point of intersection showed the ultimate or asymptotic length ($L\alpha$) of the fish (Fig. 17).

Beverton and Holt (1957) reviewed in detail, various growth equations and found Von Bertalanffy growth equation (Von Bertalanffy, 1934, 1938 and 1949) to be most superior to most of the other equations. This equation describes satisfactorily the growth of those fishes in which growth rate decreases progressively as the fish become older. Von Bertalanffy has described the growth equation by two parameters $L\alpha$, the ultimate or asymptotic length and K, the slope at which the asymptotic length is attained.

<u>Fitting of Von Bertalanffy growth equation to length at age data of *L. bata*.</u>

The equation given by Von Bertalanffy is as follows:

$$Lt = L\alpha\,(1-e^{-K\,(t-t_0)})$$

Where 'Lt' is the length at age 't', '$L\alpha$' is asymptotic length, 'e' is the base of neparian logarithms, 'K' is the coefficient of catabolism, 't' is the age of the fish and 't_0' is the age at which the fish is of zero length.

The growth equation can be fitted as follows:

$$Lt + 1 = L\alpha\ (1-e^{-K}) + Lt\ ^{e-K}$$

Here, 'Lt' and 'Lt + 1' are the length of the fish at age 't' and 'Lt + 1' respectively. This equation shows a linear relationship between 'Lt' and 'Lt + 1' (Fig. 18).

The estimated parameter is $L\alpha$ = 450 mm.

't_0' was calculated by the following formula of Ricker (1958)

$$t_0 = \frac{(\log_e L\alpha + K\ t_0) - \log_e L\alpha}{K}$$

The value of $\log_e L\alpha + K\ t_0$ is the Y axis intercept (5.99) in Fig. 18 where $\log_e(L\alpha - Lt)$ is plotted against age. Substituting the values to the above formula

$$t_0 = -\ 0.5963$$

The values of $L\alpha$, K and t_0 have been substituted in the equation. Thus Von Bertalanffy's growth equation for L. bata could be expressed as

$$Lt = 450\ (1-e^{-0.2165(t+0.5963)})$$

The values of Lt at different ages were calculated (Table 16). The theoritical lengths at different ages as calculated by this growth equation showed a close agreement between the calculated length, observed length and length determined by growth equation which revealed that Von Bertalanffy's growth equation represents adequately the growth of L. bata.

Seasonal growth:

The study of seasonal growth was made from the mean length attained during different months of the year. Growth increment has been expressed as percentage of increment to the total length at the beginning of the period as suggested by Kramer and Smith (1959) and August has been taken as the month of birth.

First year growth:

The mean monthly percentage in growth increment during first growing season of L. bata has been tabulated in Table 17 and represented graphically in Fig. 19. Three peaks were observed, first in November, second in March and third in May. A drop in average mean length was observed in January, August and December. It is quite obvious from Fig. 19 that the growth rate of first year-class was fairly good throughout the year except during January, August and December.

Second year growth:

The growth rate during the second growing season was found to be affected significantly by maturation and spawning and the drop during winter months was not so marked as in first year-class. The growth rate decreased from May to August (Fig. 19).

Third year growth:

The pattern of growth rate of third year-class was similar to that of second year-class and this year-class was also affected by maturation and spawning of the fish (Table 17, Fig. 19).

DISCUSSION

Several workers have suggested a number of factors affecting the formation of annual zones on the skeletal parts of the fish, both under natural and experimental conditions. Variations in temperature during different seasons of the year may cause the formation of opaque and translucent zones during summer and winter months of each year (Dahl, 1909; Lee, 1920). Van Oosten (1957) depicted that any cessation in the growth rate of the fish, resulted in the formation of check on the scale. Generally three main factors have been found to be responsible for growth cessation i.e. environmental, physiological and genetic (Brown, 1946).

Temperature and intensity of feeding are main environmental factors and it has been reported by several workers that temperature has a significant role in the formation of checks on the skeletal parts of the fishes from temperate regions. A drop in temperature during winter causes reduction in metabolic activity, leading to cessation or reduction in the intensity of feeding and consequently to the growth rate. During summer, temperature increases, which is followed by fast growth rate and wide scalerites (Cutler, 1918, Graham, 1929). Since the wide and narrow zones are formed by changes in temperature during different seasons and zone formation occurs only once a year, the rings are regarded as annual marks. In Rainbow trout zone formation on scale was reported to be temperature-independent by Bhatia (1931). He observed that zone formation was correlated with the abundance and scarcity of food. The fluctuation in temperature in different seasons was not as marked as it was in temperate regions and hence the ring formation can not be attributed only to temperature.

Besides environmental factor, physiological cycle of changes in the internal environment presumably lead to differential rates of growth. Variation in the secretion of endocrine gland, such as pituitary may also cause the growth retardation (Brown, 1946). She stated "since the cycle occurred in the absence of any variations of environmental factors, it can not depend on the existence of environmental makers". The maturation of gonads is usually accompanied by decreased feeding, followed by a decrease in the growth. According to Hickling (1933) "an internal factor is responsible for ring formation in the otolith of hake. The translucent band is laid down at the time of poorest condition, that is, of greatest physiological stress. In mature fish this is the exhaustion due to spawning and in immature fish to its precursor in the innate physiological rhythm which can be detached in the somatic tissue". Hartley (1947) stated that rings are "spawning marks", being produced during the spawning season of the fish. Variations in the organic nutrients have also a relationship with the growth rhythm of fish (Dannevig, 1933).

Seasonal variations in feeding intensity have also been correlated with the formation of annuli (Thomson, 1904; Hardy, 1924; Nair, 1949; Qasim, 1957; Radhakrishnan, 1957; Natarajan and Jhingran, 1963; Lakshmanan et al. 1971; Khan and Siddiqui, 1973 and Rangaswamy, 1973). Kesteven (1942) stated "feeding had ceased for a period during which resorption may have occurred at any rate at this time the circuli were differentially shortened; at the end of the period, with the resumption of feeding, scale accretion was resumed, but in such a manner as to produce complete circuli lying at a different angle to those of the previous annulus".

The formation of scale in immature fishes reflects an innate physiological rhythm in comparison with the spawning cycle of the adult. The reduced feeding and the maturation of gonads occur simultaneously and cause the periodic formation of the rings on the scales.

Pillay (1953) stated that the upsetting of bottom flora by floods caused the reduced feeding and consequently the growth, was checked. Seshappa and Bhimachar (1951) while working on the scales of Cynoglossus semifasciatus, suggested that the rings were formed under the influence of South West monsoon which resulted in the depletion of food at the bottom. This lack of food led to starvation which was the main factor in the formation of rings and they named these rings as monsoon rings. Similar findings have been reported by Jhingran (1957) in Cirrhina mrigala. The migration of the fish from one environment to another annually for spawning or feeding purposes may also cause the formation of annuli.

Many workers have observed the growth check on the skeletal parts of tropical or subtropical fishes (Hornell and Naidu, 1924; Nair, 1949; Seshappa and Bhimachar, 1951; Menon, 1953; Pantulu, 1961, 1963; Natarajan and Jhingran, 1963 and Kamal, 1969). Delsman (1929) and Hardenberg (1938) reported that due to absence of severe winter in tropical regions, a periodicity in growth of the fishes did not occur and thus the scales possessed no growth rings. This statement was not supported by significant evidences because in tropical waters, there is a periodicity in the physico-chemical and biological factors of the water and periodic rhythm in spawning. Menon (1950) criticised that without detail examination of this important problem on the lines suggested by Graham (1929) and Van Oosten (1929) this view can not be accepted. Qasim (1957) summarised "higher temperature and increased food intake during summer, after spawning, lead to a rapid growth in length and that the densest opacity appears during this time. On the other hand the period of lowest temperature and lowest intake of food is followed by formation of the transparent zone, which coincides with the highest rate of gonad maturation and breeding activity".

In L. bata it has been observed that the first year ring formed during the month of March or April. The intensity of feeding was found to be lowest during these months and moderate during rest of the months. This shows that ring formation during the first year of life may be correlated to low feeding intensity. In second year-class or above year-classes, ring formation occurred during April to June which were the spawning months of the fish. During spawning period, gonads enlarge enormously and most of the growth potential is directed towards the gonad building. The space for gut is also reduced due to enlargement of gonads which causes low feeding. Examination of outer margin of scale of L. bata revealed that ring on the margin occurred only once a year and so these rings were termed as true annuli.

A comparison of the growth rate in various age groups shows that growth is more rapid during first four years of L. bata. A progressive decrease in the rate of growth with increase in age, has been observed. Decrease in calculated lengths with increasing age has been attributed to attainment of maturity and it is well known fact that most of the growth potential is used for gonad building rather than dimensional growth after second year-class. Mraz (1964) reported a complete reverse case to the above statement in the case of round white fish. He noted an increase of calculated length with the increase in age in the above mentioned fish.

Lee's phenomenon of apparent changes was thoroughly discussed by Smith and Pycha (1961). According to them the larger and faster growing fishes have a greater mortality rate and are caught early in the life than the slower growing fishes. Panikkar (1949) stated "if we are to go by the size of fish and the rapid growth under tropical conditions, where the rate of metabolic activities increases at least three times what it is in colder latitudes, the maximum size to which most species grow may be attained within a course of 10-12 months".

A certain degree of size overlapping was found in both the sexes due to wide range of sizes among the fishes of same year-class (Qasim, 1957; Frost and Kipling, 1967). This overlapping was partly due to prolonged breeding season of the fish and spawning of all the individuals did not complete at one time.

So some fishes hatch earlier than others and stand to gain a good start of life. Qasim (1957) suggested that the range of sizes in each year class comprise not only their size at their respective birth days, but also the length increments between one year and the next age group. Size of the fish is most important factor which affects the growth on the population (Brown, 1946). Larger fishes have found to grow comparatively faster because they prove to be more efficient in competition and able to attain maximum food than the juveniles and removal of larger fishes from the environment leads to an improvement of the growth rate of smaller fishes.

Beverton and Holt (1957) attempted to compute the growth of a number of fishes according to Von Bertalanffy growth equation. According to Von Bertalanffy's (1938) growth equation, an organism is analogous to a reacting chemical system obeying the law of mass action and the growth (mass) is the net result of the interaction between two generally opposing processes, catabolism (breakdown) and anabolism (Synthesis).

In L. bata Von Bertalanffy growth equation describes the growth of the fish significantly because the fish constantly inhabits one environment throughout the life, thus leaving aside the chance of revising the ultimate length.

The seasonal growth curve of L. bata indicates that growth in length almost entirely occurred in the post spawning months of the year. The growth curve of first year-class showed two maxima, first in November and second in May. These two maxima also indicate the two peak periods of feeding. A sharp decline in growth rate during April to July was due to enlargement of gonads in adult fishes. This shows that the food intake is used entirely for gonad building and courtship activities. An increase in growth rate during post monsoon months was due to better feeding.

To summarize the pattern of growth rate of *L. bata* it can be said that the growth curve of the fish of first year class was affected only by food uptake while the growth rate of adult fishes was influenced by intensity of feeding as well as maturation of gonads.

SUMMARY

Age and growth of *L. bata* (Ham.) was studied by the analysis of scales and length frequency distribution. Scale pattern of this fish shows the growth check in the form of carved out spaces in circuli. These marks are annular in nature and are suitable for age determination. A differentiation was found between false rings and true growth rings. The least amount of abnormality was found in scales in the region just below the dorsal fin and above lateral line and about 15% of the scales were abnormal.

The causative factor of annular ring formation in the fishes of first year-class was found to be the intensity of

feeding where as in adult fishes, the ring formation was influenced by both feeding intensity and maturation cycle.

L. bata was found to attain a length of 131 mm, 194 mm, 236 mm, 277 mm, 314 mm, 341 mm and 364 mm at the end of Ist, 2nd, 3rd, 4th, 5th, 6th and 7th year of life respectively. Increase in length of the scale was observed to bear a constant ratio to the increase in length of the fish and regression analysis yielded a straight line relationship between scale and body length. The calculated values could be expressed as :

$$Y = - 2.534 + 0.064 X$$

The growth rate of the fish was found to be high during Ist and 2nd years of life after which the rate decreased gradually upto the age group VII. Both sexes showed a similar growth rate and attained a similar longevity. Lee's phenomenon of apparent changes in growth rate was also recorded.

Growth of the fish confirmed the Von Bertalanffy's growth equation and could be expressed as

$$Lt = 450 \ (1-e^{-0.2165(t \ + \ 0.5963)})$$

Seasonal growth curve was chiefly influenced by feeding intensity in the fishes of first year-class while in adult fishes the seasonal growth curve was affected by feeding intensity as well as maturation of gonads.

Plate 1. Total length of the fish : 206 mm
shows one ring.

Plate 2. Total length of the fish : 245 mm
shows two rings.

Plate 3. Total length of the fish : 266 mm
shows three rings.

Plate 4. Total length of the fish : 311 mm
shows four rings.

Plate 5. Total length of the fish : 365 mm
shows five rings.

Plate 6. Total length of the fish : 429 mm
shows six rings.

Plate 7. Total length of the fish : 443 mm
shows seven rings.


PLATE 1.


PLATE 2


PLATE 3


PLATE 4

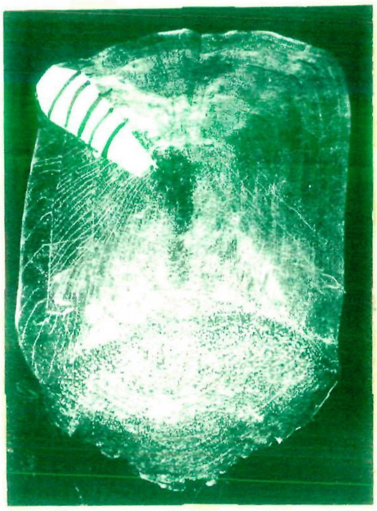


PLATE 5


PLATE 6

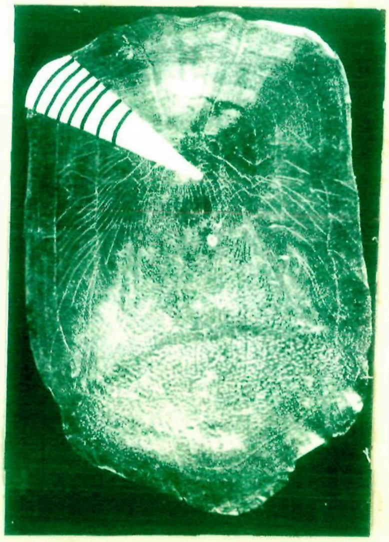


PLATE 7

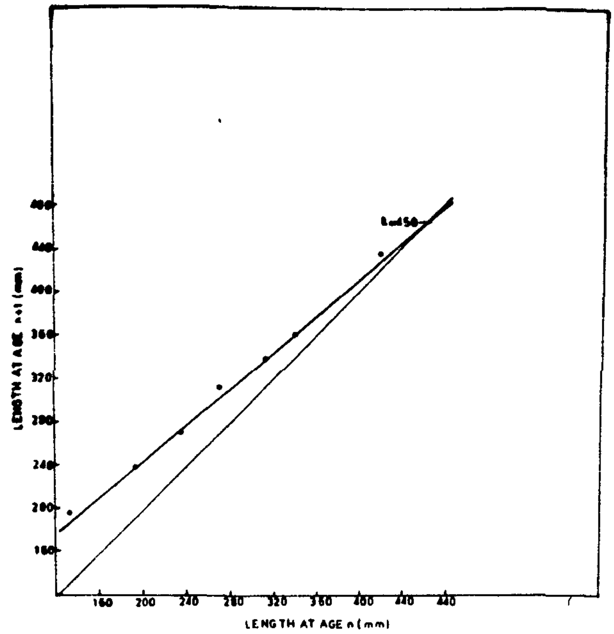


FIG.17

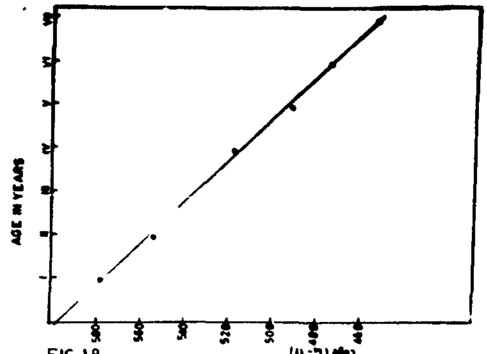


FIG.18

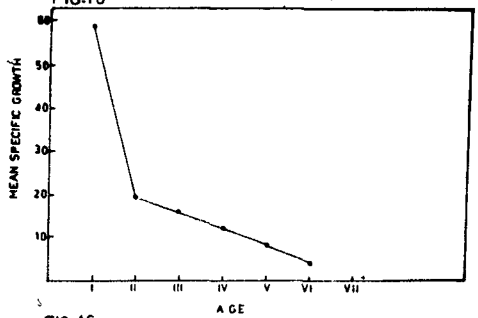


FIG. 16

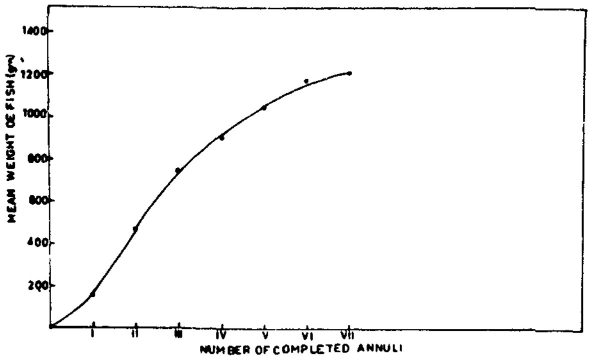


FIG.15

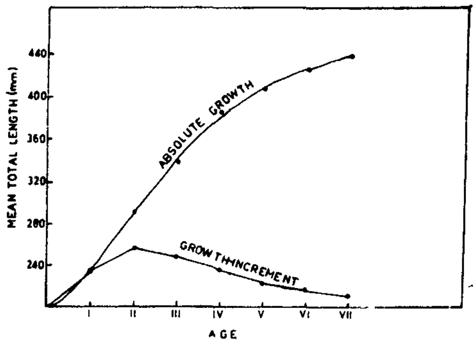


FIG.14

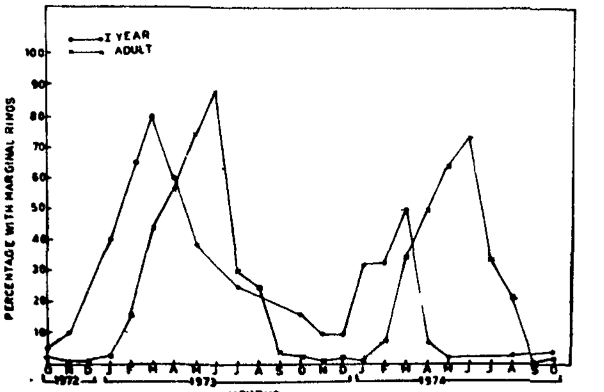


FIG.12

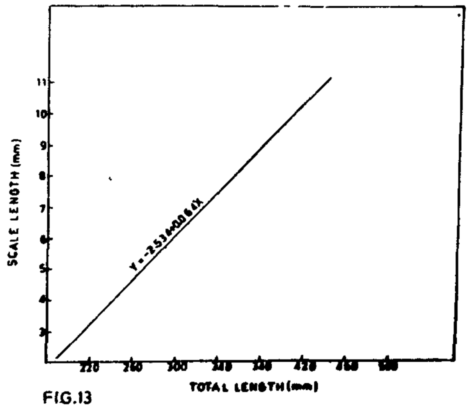


FIG.13

Fig. 19. Seasonal growth curve of L. bata.

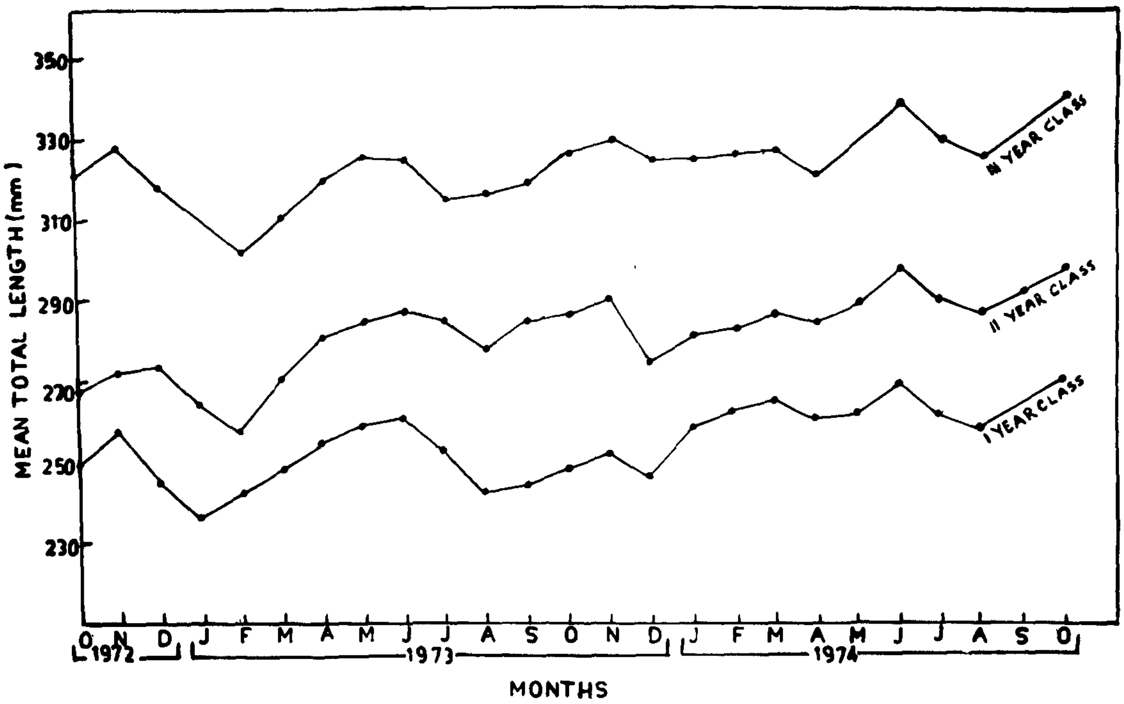

MEAN TOTAL LENGTH (mm)
350
330
310
290
270
250
230
III YEAR CLASS
II YEAR CLASS
I YEAR CLASS
O N D J F M A M J J A S O N D J F M A M J J A S O
1972
1973
1974
MONTHS

FIG.19

TABLE - 14

LENGTH FREQUENCY DISTRIBUTION OF AGE GROUPS

Size group (mm)	AGE GROUPS						
	I	II	III	IV	V	VI	VII
150 - 200	110	-	-	-	-	-	-
201 - 250	25	18	-	-	-	-	-
251 - 300	8	89	20	8	-	-	-
301 - 350	-	5	80	12	3	1	-
351 - 400	-	-	2	79	6	1	-
401 - 450	-	-	-	-	16	6	2
Total number of fishes	143	112	102	99	25	8	2
Percent of total	28.6	22.4	20.4	19.8	5.0	1.6	0.4

TABLE - 15

CALCULATED LENGTH AT EACH ANNULUS AS DETERMINED BY BACK CALCULATION

Age	Calculated length at different annuli (mm)						
	I	II	III	IV	V	VI	VII
1	177	-	-	-	-	-	-
2	163	236	-	-	-	-	-
3	140	219	290	-	-	-	-
4	125	208	254	305	-	-	-
5	111	180	221	277	217	-	-
6	105	170	211	267	314	342	-
7	101	151	204	259	311	340	364
Grand Mean	131	194	236	277	314	341	364

TABLE - 16

MEAN CALCULATED LENGTH AT EACH ANNULUS, GROWTH INCREMENT, RELATIVE GROWTH AND SPECIFIC GROWTH RATE

Age group	Back calculated length (mm)	Length determined by growth equation	Growth increment	Relative growth (%)	Specific growth (%)
I	131	129.6	131	36.0	59.63
II	194	177.0	63	17.3	19.59
III	236	226.5	42	11.5	16.02
IV	277	267.0	41	11.3	12.52
V	314	312.5	37	10.2	8.26
VI	341	339.0	27	7.4	6.51
VII	364	359.1	23	6.3	-

TABLE 17

MEAN MONTHLY GROWTH RATE OF L. BATA

Months	FIRST YEAR		SECOND YEAR		THIRD YEAR	
	Mean length (mm)	% of total annual growth	Mean length (mm)	% of total annual growth	Mean length (mm)	% of total annual growth
October 1972	250	-	268	-	321	-
November	258	3.2	272	1.4	328	2.1
December	245	-5.0	274	0.7	318	-3.0
January 1973	237	-5.0	264	-3.6	-	-
February	242	2.3	258	-2.2	302	-
March	248	2.4	271	5.0	310	2.6
April	255	2.8	281	3.6	319	2.9
May	259	1.5	284	1.0	325	1.8
June	261	0.7	287	1.0	324	-0.3
July	252	-3.4	285	0.6	315	-2.7
August	242	-3.9	278	-2.4	316	0.3
September	244	0.3	285	2.4	318	0.6
October	248	1.6	286	0.3	326	2.5
November	252	1.6	290	1.3	329	0.9
December	246	2.3	274	-5.5	323	-1.8
January 1974	260	5.6	281	2.5	-	-
February	262	0.7	282	0.3	325	-
March	265	1.1	286	1.4	326	0.3
April	260	-1.8	284	-0.6	320	-1.8
May	261	0.3	289	1.7	342	6.8
June	269	3.0	298	2.4	345	0.8
July	260	-3.3	289	-3.0	339	-1.7
August	253	0.7	286	-1.0	325	-3.8
September	-	-	-	-	-	-
October	270	-	298	-	340	-

CHAPTER V

FOOD AND FEEDING HABITS

INTRODUCTION

The study of food and feeding habits of fishes is as old as the fishery science. Most of these investigations report the food of the fish and its variation with season, sex and size of a single species in an environment. Few accounts are also available on the ecological aspects like intensity of feeding and factors affecting it (Ivlev, 1961), food selection (Allen, 1941; Hess and Swartz, 1941; Lewis *et al*. 1961 and Cramer and Marzolf, 1970) and feeding relationship and competition (Hartley, 1948; Thomas, 1962; Maitland, 1965 and Khan and Siddiqui, 1973).

From India the food and feeding habits of the following freshwater fishes have been reported: *Labeo rohita* (Sarbhi, 1939; Das and Moitra, 1955a, 1955b and Vasisht, 1960), major carps (Mookerjee and Ghosh, 1945), *Cirrhina mrigala* (Chakrabarty and Singh, 1963), *Pangasius pangasius* (David, 1963), *Catla catla* (Natarajan and Jhingran, 1963), *Ophicephalus punctatus*, *Barbus stigma* and *Callichrous bimaculatus* (Qayyum and Qasim, 1964a, 1964b and 1964c) and *Mystus seenghala* (Saigal, 1964). A detailed account of food and feeding habit of *Labeo rohita* has been given by Khan (1972).

Inspite of considerable importance of *L. bata* as a food fish nothing is known about the diet of this species either in the rivers or lakes. Therefore a detailed study of the food and feeding habits of L. bata in river Kali was made and reported here.

MATERIALS AND METHODS

Monthly samples were obtained for a period of 25 months, from October, 1972 to October, 1974 and a total number of 575 specimens of Labeo bata, 70 mm to 415 mm (total length) were examined. The fishes were caught by gill nets during the early hours of morning and brought to the laboratory in ice.

Each fish was measured upto the nearest millimeter from the tip of the snout to the longest ray of caudal fin, weighed nearest to 0.1 g and sexed. State of maturation was determined following the scheme of classification used for Ophicephalus punctatus (Qayyum and Qasim, 1964a). The guts were taken out carefully from the oesophagus to the last part of intestine, weighed upto nearest 0.5 g and preserved in 10% formalin.

For the analysis of gut content of the fishes, several methods have been followed which have been critically reviewed by Hynes (1950) and Pillay (1952). During the present investigation number method as described by Allen (1938 and 1941), Frost (1939), Frost and Went (1940), Radforth (1940), Hynes (1950) and Khan (1972) was followed.

Food items were generally found uniformly distributed throughout the alimentary canal and for this reason it was necessary to examine the whole gut contents. Five pieces of the gut, each measuring about 50 mm were taken from different parts of the gut (Fore, mid and hind) in a petri-dish containing known quantity of water and all the food was removed carefully. It was then thoroughly mixed and out of this 0.5 ml was taken on a slide with the help of a graduated dropper and examined under the microscope.

As far as possible, various planktonic feed items were identified upto generic level and counted. Their relative abundance was expressed as percentage of total number of food items in the sample. The process was repeated by examining another sample of 0.5 ml and a mean of the two was obtained. However, the percentage of decayed organic matter and sand and mud were decided by eye estimation and it was found that after a good practice, it gave satisfactory results.

The intensity of feeding was studied by determining the gastro-somatic index (gut weight expressed as percentage of body weight). The number of fishes with empty guts were also noted in each month and expressed as the percentage of total number of fishes examined in that month.

The food selection and availability of food was studied by the method described by Ivlev (1961). The "Electivity Index

(E)" was calculated by the following formula:

$$E = \frac{ri - pi}{ri + pi}$$

Where 'ri' is the relative content of any ingradient in the ration expressed as percentage of whole ration and 'pi' is the relative value of the same ingradient in the food complex of environment expressed as percentage. The value of 'E' may range within a limit of -1 to +1, the former denotes a complete negative selection while the later indicates the exclusive positive selection for a food. A value of 0 represents a complete absence of any selection.

The contents of the hind gut were also examined carefully to ascertain the presence of undigested food matter. The state of digestion and importance of various algal food organisms, were recorded.

RESULTS

From the study of organs of feeding and their structural modifications, it becomes clear that the fish is herbivorous, feeding mainly upon aquatic vegetation and phytoplankton. The mouth, lips, buccal cavity, gill rakers and gut are well adapted for this mode of feeding. Absence of teeth, depressed buccal cavity, absence of tongue, modified gill rakers for seiving and filtration of phytoplankton, absence of true stomach, shows that these fishes are herbivorous.

FOOD COMPOSITION

Food composition and its variation with season:

Percentage occurrence of different food items in different months of the year is given in Table 18 and presented graphically in Figure 20.

The analysis of gut contents showed that green algae, diatoms, blue green algae, desmids,phytoflagellates, algal spores and zygotes, macrovegetation, decayed organic matter, rotifers and protozoans were the main food items of adult fishes. In fingerlings zooplankton were found to be the main food but as the fishes grew they changed their feeding habits from zooplanktonic to phytoplanktonic food items. These food items were invariably found along with the sand and mud which indicated that they were consumed from the bottom zones.

Phytoplankton formed the main bulk of the food of the adult fish and occurred throughout the period of study in considerably large amounts. It constituted about 60% of the total food. Green algae and diatoms formed the two major components of the phytoplanktonic organisms constituting more than 40% of the total food.

GREEN ALGAE (Chlorophyceae)

In L. bata green algae constituted about 16% of the total food. Spirogyra was the most important green alga, occurring regularly in the gut of this species. It was in greater proportions in the months from January to May in both the years. Scenedesmus and Crucigenia were other important food items and occurred consistently. Ankistrodesmus, Tetraspora, Pediastrum, Selenastrum and Oedogonium were of lesser importance (Table 18).

DIATOMS (Bacillariophyceae)

Diatoms formed about 20% of the total food. They occurred fairly in large amounts throughout the period of investigation. The contribution of Navicula was maximum among all diatoms throughout the period of study and it constituted about 7% of the total diatoms. Next to Navicula were Cyclotella, Diatoma, Nitzschia and Gyrosigma. Except Gyrosigma, which was not recorded in few months, rest of these genera were found in all the months (Table 18). Synedra and Surirella were recorded only in few months. Cymbella and Cocconeis were also found in considerable amounts (Table 18).

BLUE GREEN ALGAE (Myxophyceae)

Blue green algae were also encountered all the year round except in few months. Microcystis and Phormidium were the main constituents of blue green algae. Nostoc and Anabaena were also encountered during most of the months but their percentage were very low.

DESMIDS (Desmidiaceae)

Only two genera *Cosmarium* and *Closterium* were recorded and these two genera constituted about 2% of the total food.

PHYTOFLAGELLATES

Volvox formed only 1% of the total food occurring only in few months.

ALGAL SPORES, ZYGOTES AND MACROVEGETATION

Algal spores and zygotes, though formed a portion of the diet of *L. bata*, occurred throughout the period of study. Macro-vegetation which included portions of higher aquatic plants and decayed organic matter of dirty green or brown colour, also formed a significant portion (percentage) of the diet and occurred throughout the year.

ROTIFERS

Keratella was found in a very low percentage and occurred only in few months.

SAND AND MUD

The quantity of sand and mud was very high. It constituted about 28% of the total food.

Food composition and its variation with size:

The food of different size groups of *L. bata* (Table 19) ranging from 200 to 450 mm vary significantly. The food of fishes below 200 mm was not included in this table. However, the fishes below 200 mm were found to feed mainly on zooplankton (Table 20, Column 1), while the larger fishes consumed bigger algae, macrovegetation and decayed organic matter.

FOOD SELECTION

Food preferences of 110 fingerlings and 205 adult of *L. bata* were investigated. The percentages of various food items in gut contents (ri), percentage of the same items in the environment (pi) and Electivity index (E) of fingerlings and adults of *L. bata* are tabulated in Table 20. Figure 24 shows Electivity indices of different major groups of food items. A strong positive selection for all the zooplanktonic organisms and for some smaller phytoplankton like desmids, phytoflagellates and algal spores and zygotes was shown by fingerlings. Other phytoplanktons, like green algae, diatoms and blue green algae, were not preferred and were in low proportion. Rotifers (*Keratella*, *Brachionus*), Cyclops (*C. strenus*, *C. viridis*) and Cladocerans (*Daphnia*, *Cerato-daphnia*, *Moina*) were consumed heavily.

On the other hand adults showed a strong positive selection for all the phytoplanktonic organisms. Green algae and diatoms were the most preferred food organisms. Zooplanktonic organisms, like protozoans, rotifers and crustaceans, were avoided and consequently values of 'E' were found to be negative (Table 20, Fig. 24).

Variation in food with sex:

No significant difference was noted in the food composition of males and females.

INTENSITY OF FEEDING:

Intensity of feeding in relation to season:

Gastro-somatic indices (alimentary canal weight as percentage of body weight) of *L. bata* along with the percentages of empty guts are given in Table 21 and represented graphically in figure 21. The values of gastro-somatic indices were found to be inversely proportional to the percentages of empty guts. Minimum intensity of feeding was recorded during the monsoon months (June to September) and most of the guts either contained little food or were empty. The feeding activity increased in October and active feeding was recorded upto February. From March onward the feeding intensity declined and reached its lowest level during the monsoon months.

Intensity of feeding in relation to size:

The average feeding intensity and percentage of empty guts at each size class of *L. bata* are given in table 22 and shown in figure 22. It may be noted that the feeding intensity increased as the fish increased in size and reached the highest level in class III (251-200 mm). Afterwards the feeding intensity decreased and continued at a moderate rate.

Intensity of feeding in relation to sexual cycle:

The intake of food subject to significant variations from season to season. This variation to a large extent, seems to be correlated with the breeding season of the fishes. Feeding is considerably reduced in ripe fishes, particularly in females.

Table 23 and figure 23 show that in both the sexes the intensity of feeding was higher in immature fishes (Stage I). Intense feeding was also recorded in maturing and ripening (stage II & III) fishes whereas the ripe fishes consumed less amount of food.

Intensity of feeding in relation to sex:

A noticeable difference was observed in the feeding intensity of the two sexes during the spawning period. The intensity of feeding in males was higher than the females during the spawning months and as a whole feeding was found better in males throughout the year than in the females.

DISCUSSION

The predominant occurrence of green algae, diatoms, blue green algae, desmids, phytoflagellates, algal spores and zygotes and macrovegetation in the gut of L. bata strongly suggests that this species feeds mostly on plant matter. It was noted that the fish gorged their gut with fine and soft decayed organic matter, fresh algae, diatoms, along with sand and mud. The herbivorous type of feeding habit is also supported by the structural modification of the organs of feeding. Zooplankton formed a very small proportion of the diet though it formed the main bulk of the food of fingerlings. The zooplanktonic organisms are negatively selected and the occurrence of rotifers, crustaceans in the guts may be accidental. The presence of sand and mud in the gut of these fishes, furnishes evidence about their feeding at the bottom.

In fact, unlike marine habitats, the ecological zones in the freshwaters based on physical and chemical nature of water and fauna and flora inhabiting it, are not sharply demarcated from each other. Larkin (1956) while commenting on the vague demarcation of the fish fauna of the ecological zones in freshwater environment, stated that a sharp demarcation of the fish fauna within these zones is not possible and concluded that freshwater communities would seem to be characterised by more breadth than the height - the pyramid of food chain - a complexity in horizontal organisations. Therefore, it becomes quite difficult to conclude whether L. bata feeds at one zone or other. The sharp demarcation of zones becomes difficult in shallow rivers and the fish can explore all the zones vertically, very easily.

Relative importance of different food organisms varied from month to month. Such variations are due to varied production of the food items in the environment. The percentage of food items varied from month to month and a particular type of food item tends to be maximum at a particular time and this is due to succession of species in the population.

The appearance of different types of algae in gut contents in different months of the year depends on their availability rather than on selection by the fish. L. bata is a non-migratory fish and remains in one habitat throughout its life and has to adapt to the food available in the rivers during different seasons of the year. The more readily available the food organism, the more it is taken by the fish.

The occurrence of phytoplankton in the gut of the fish was recorded throughout the year and its total percentage almost remained the same. If the occurrence of one group was in lesser quantity, it was replaced by another group of phytoplankton. Except desmids, all the major groups of phytoplankton were always found consistently in the gut of the fish.

The occurrence of decayed organic matter, detritus (seston) in the gut was quite high in monsoon months and the incoming flood water appears to be the main source of organic matter. The percentage of decayed organic matter was quite low during winters.

Fishes are known to change their feeding habits as they grow. Nikolsky (1963) suggested that variation in the composition of the food with age and size is a substantial adaptation towards increasing the range of food supply of population by enabling the species as a whole to assimilate a variety of food. Alikunhi (1952) and Mitra and Mahapatra (1956) after experimental studies on the feeding of fry of major carps concluded that fry fed mainly on zooplankton and avoided phytoplankton. Khan (1972) also found zooplankton as the dominant food of fry and fingerlings of major carps (L. rohita, C. mrigala and C. catla) and as the fish grew it gradually changed its food from zooplankton to phytoplankton in the first two species while the later remained primarily a zooplankton feeder.

Smaller fishes were found to consume crustaceans, rotifers and protozoans. Among phytoplankton smaller forms of algae like desmids, phytoflagellates, Navicula, Cyclotella, and Scenedesmus were preferred by smaller fishes while filamentous algae like Spirogyra and Zygnema were eaten mostly by the bigger fishes. From this study it become quite evident that L. bata definitely feeds selectively. The selection of food items takes place at two stages of the life, at fingerling stage they selected against most of the phytoplanktonic organisms while in the second stage (adult) they selected against the zooplanktonic organisms.

There appears to be no particular preference for any particular species of phytoplanktons, as the fish feed on available ones. Bhatnagar and Karamchandani (1970) also reported similar condition in case of Labeo fimbriatus. Prakash (1962) found in salmon that its food changes with its locality and time (season) and sometimes when the normal food was not available, salmon would feed on alternate food. Ivlev (1961) suggested that the tendency of a particular animal to consume certain food items selectively in comparison to others, is determined by its inherent properties.

Feeding relationship and competition for food among the species of the same community specially allied species has been discussed by many workers and reviewed by Hartley (1948), Nilson (1957) and Thomas (1962). Hartley (1947) and Frost (1950) found that some of the closely related species occupy almost similar feeding niche within the community. Hartley (1948) stated that such community consists of a number of generalized feeders forming a closely organized assemblage distinguished by no more than varying properties in which they draw the constituents from a common stock.

The present study shows that there is no true identity of food habits between L. bata and L. gonius and they appear to occupy the same feeding niche. However, with the present state of knowledge it is very difficult to demonstrate whether there is any inter-species competition or not.

Khan (1972) stated that there was a competition for food among the fingerlings of L. rohita, C. mrigala and C. catla because all of them were found to feed on similar types of zooplankton and as they grew they changed their feeding habits. The feeding on zooplankton was for a short time and this change in the feeding habits may be judged in the light of Lack's (1945) statement that when a particular type of food is in short supply, then only one species will survive and under such conditions each species turns to a different feed and this way there would be no competition.

Like other tropical fishes, the intensity of feeding of adult L. bata was also affected by maturation. Low feeding from March upto June was due to development of gonads and during peak ripeness (June), the minimum feeding took place. Feeding intensity was also low during monsoon months. Suseelan and Somasekharan (1969) also reported similar feeding rhythm in demersal fishes of Bombay.

The rate of food intake increased in the post monsoon months. This increase in the food intake can be associated with the stablised conditions of the environment when more food becomes available. The spent fishes consume more food to recover from the exhaustion and for gonad building.

Almost the same intensity of feeding was observed in both the sexes. The temperature was not found to influence the intake of food.

SUMMARY

The food of L. bata (Ham.) consists chiefly of phytoplankton (green algae, diatoms, blue green algae, desmids, phytoflagellates, algal spores and zygotes), macrovegetation and decayed organic matter (Seston). Zooplankton are very rare in the diet of the adult fishes. However, zooplanktons are the main food of fingerlings and as the fish grew, they changed their feeding habits from zooplankton to phytoplankton. Green algae and diatoms were the most important food items and constituted about 40% of the total food. The stomachs of all the fishes contained sand particles which were ingested while feeding at the bottom.

The intensity of feeding was found to be maximum during post-monsoon (October-November) and winter months (December-February) and low during post-winter (March-April), summer (May and June) and monsoon months (July-August). The increased feeding intensity in winter corresponds to a period of algal blooms in the water. During rainy season, the river gets flooded and contains less amount of food and this appears to influence the feeding intensity. Besides, the maturation of gonads was also found influencing the feeding intensity. Minimum food intake was found in ripe fishes.

No difference was noted between the food of males and females.

L. bata was definitely selective in feeding as the fingerlings showed a positive selection for all the zooplanktonic organisms while the adult showed a negative selection for all the zooplanktons and a positive selection for all the phytoplanktonic organisms.

Fig. 20. Seasonal variations in the percentage composition of food of *L. bata*.

Fig. 21. Seasonal variations in the intensity of feeding of *L. bata*.

Fig. 22. Variations in the intensity of feeding with the size of *L. bata*.

Fig. 23. Variations in the intensity of feeding with maturity stages of *L. bata*.

Fig. 24. The electivity indices (E) of different groups of food items.

TABLE 18

MONTHLY VARIATIONS IN THE PERCENTAGE COMPOSITION OF DIFFERENT FOOD ITEMS OF

LABEO BATA

Food items	1972			1973												1974										Mean
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct	
Oedogonium	-	-	0.4	0.5	0.1	-	0.5	0.1	-	-	-	2.5	3.2	2.1	3.5	4.5	2.5	2.1	1.2	0.7	0.3	0.5	-	-	2.5	1.6
Pediastrum	0.1	0.3	0.7	0.6	0.2	0.3	0.3	-	-	-	2.5	0.4	2.1	3.1	4.0	4.8	1.7	3.0	2.4	0.4	0.2	-	0.7	1.2	2.5	1.5
Selenastrum	0.2	0.4	0.8	-	-	0.1	-	0.2	0.1	1.0	1.4	-	0.8	2.7	1.0	3.8	2.0	1.0	2.0	1.4	1.1	0.5	1.6	1.1	4.5	1.2
Ankistrodesmus	2.8	3.9	4.1	3.9	-	1.5	0.5	0.3	0.2	-	1.0	1.2	0.9	3.2	3.9	6.8	1.2	3.8	3.6	0.3	1.1	0.1	0.1	2.5	2.6	2.1
Scenedesmus	1.5	3.1	3.8	2.5	-	-	9.8	7.5	1.1	1.8	2.4	3.0	1.7	4.4	4.8	2.5	1.3	2.9	4.7	10.0	3.8	1.2	0.5	1.2	5.5	3.5
Spirogyra	0.1	0.1	0.5	4.1	6.1	7.2	12.4	9.5	2.2	1.2	1.2	1.5	0.5	3.4	2.9	9.2	1.0	6.0	7.2	-	2.2	1.5	2.6	1.9	2.8	3.6
Tetraspora	2.8	2.9	3.1	-	-	-	-	-	-	-	-	-	5.8	5.7	6.5	3.8	3.2	3.5	2.2	1.7	-	-	-	0.5	2.5	3.4
Crucigenia	3.6	-	3.8	5.2	1.1	3.9	3.4	2.1	0.4	-	-	2.8	6.5	5.8	3.7	2.8	2.5	2.9	6.0	3.2	1.9	-	0.8	-	5.9	3.4
GREEN ALGAE	11.2	10.7	17.2	15.8	7.4	12.9	14.6	19.7	4.4	4.0	8.5	11.4	21.5	30.4	30.3	38.2	15.4	25.2	29.3	17.7	10.6	3.8	4.6	8.4	28.8	16.0
Cyclotella	15.2	16.1	16.4	10.5	1.1	0.9	4.0	2.9	0.5	1.5	3.9	3.7	2.8	2.4	2.5	7.8	1.9	2.9	5.0	2.0	1.8	1.9	1.8	4.1	3.0	4.6
Diatoma	2.3	1.2	1.4	1.0	7.8	4.2	1.3	1.1	0.2	2.2	0.5	2.7	1.1	3.4	2.6	2.0	8.1	7.8	2.1	1.5	2.6	3.1	1.0	1.0	2.9	2.6
Nitzschia	6.5	5.6	4.2	2.0	1.2	0.9	1.3	0.8	0.1	0.7	1.0	0.9	0.4	0.7	0.9	3.0	2.5	-	1.9	0.3	3.0	3.2	1.9	2.0	2.5	1.9
Naviculla	13.7	14.7	16.5	17.6	10.2	15.8	7.5	4.9	1.2	3.5	1.5	7.6	2.3	6.0	2.6	10.5	21.6	6.8	1.2	2.5	1.0	1.5	2.0	1.0	2.3	7.0
Cymbella	0.6	0.3	0.4	5.8	1.4	0.5	0.8	0.8	0.1	0.5	-	1.7	1.5	3.7	-	2.5	1.3	-	1.2	0.2	1.3	2.0	2.6	9.5	1.9	1.8
Gyrosigma	2.1	1.5	10.6	5.6	1.1	7.3	0.6	0.7	0.1	-	-	-	0.1	0.3	1.4	3.5	0.5	0.5	0.2	-	0.1	0.1	1.7	0.5	1.0	1.9
Cocconeis	1.6	1.9	2.1	3.1	0.8	4.8	0.5	0.2	-	-	0.5	0.7	-	-	1.3	1.2	-	1.0	-	-	0.4	-	-	0.8	1.3	1.5

Synedra	-	0.1	0.2	2.8	-	-	0.9	0.6	-	1.7	0.7	0.7	0.8	1.1	-	3.0	1.2	-	-	0.2	0.5	-	-	1.5	1.5	1.0
Surirella	0.2	0.1	0.4	1.9	2.1	0.2	-	-	-	-	-	1.0	1.5	0.7	-	2.5	-	2.3	0.3	0.3	1.3	1.5	2.0	2.0	0.5	1.1
DIATOMS	32.2	41.5	42.2	48.3	25.7	27.6	16.1	11.9	2.2	10.1	8.1	18.8	10.5	18.3	11.3	36.0	37.1	21.3	11.9	8.0	11.8	13.3	13.0	22.4	17.2	20.6
Nostoc	0.2	0.1	2.1	2.0	1.5	-	1.2	2.6	-	1.8	-	0.5	2.1	1.2	2.5	-	1.9	2.5	3.0	3.0	3.5	3.6	1.2	-	1.2	1.8
Anabaena	0.1	0.1	1.0	-	0.9	-	1.0	0.9	-	-	1.0	0.1	1.1	-	1.1	1.5	1.0	-	1.2	2.1	2.8	2.9	-	-	1.0	1.1
Microcystis	0.6	0.4	0.2	-	0.1	-	0.1	3.1	-	4.5	1.5	2.8	2.1	1.3	3.8	3.2	2.5	3.0	4.1	3.5	4.0	4.8	2.5	1.3	2.5	2.2
Phormidium	1.4	0.6	2.5	1.2	2.1	-	2.3	2.2	-	3.0	2.5	1.0	2.8	1.1	1.3	1.0	1.1	2.5	0.7	2.1	1.2	1.4	2.2	2.2	1.7	1.7
BLUE GREEN ALGAE	2.3	1.2	6.3	3.2	4.6	-	4.6	8.8	-	9.3	5.0	4.4	8.1	4.8	8.2	5.7	6.5	8.1	9.0	10.7	11.5	12.7	5.9	3.5	6.4	6.5
Cosmarium	-	0.1	-	0.2	1.0	0.8	-	-	-	0.1	1.2	0.8	0.5	1.1	1.5	0.5	2.5	0.9	0.3	0.3	0.7	-	3.2	2.5	1.0	1.0
Closterium	2.5	3.2	2.1	1.5	1.0	1.1	-	-	-	-	0.9	1.5	1.2	1.0	1.4	1.1	1.8	1.2	1.2	0.9	1.2	-	1.1	1.5	-	1.4
DESMIDS	2.5	3.3	2.1	1.7	2.0	1.9	-	-	-	0.1	2.1	2.3	1.7	2.1	2.9	1.6	4.3	2.1	1.5	1.2	1.9	-	4.3	4.0	1.0	2.2
Volvox	0.3	0.1	-	0.5	-	-	0.1	-	-	-	0.9	0.7	2.2	0.4	1.0	2.5	1.2	-	0.1	-	-	-	-	-	2.3	0.9
PHYTOFLAGELLATES	0.3	0.1	-	0.5	-	-	0.1	-	-	-	0.9	0.7	2.2	0.4	1.0	2.5	1.2	-	0.1	-	-	-	-	-	2.3	0.9
ALGAL SPORES & ZYGOTES	18.1	6.5	5.2	3.2	3.1	5.6	5.3	6.9	7.9	9.2	9.3	11.5	14.8	7.8	6.2	4.5	4.8	6.8	5.2	6.9	7.0	10.5	11.5	12.2	10.1	8.0
MACROVEGETATION	5.7	4.8	3.2	3.0	4.1	4.8	4.9	5.2	5.0	7.5	3.1	3.0	3.2	4.8	2.2	2.0	3.5	3.0	2.5	2.0	3.2	5.8	4.1	4.0	4.9	4.0
DECAYED ORGANIC MATTER	30.6	22.9	16.2	10.1	17.5	8.5	7.8	10.5	25.5	13.5	14.8	22.1	27.0	18.5	8.6	4.3	24.4	7.2	10.3	8.6	17.3	12.9	13.1	20.5	25.5	15.9
Keratella	0.3	0.1	-	0.3	-	-	-	-	-	0.1	-	4.5	2.2	3.6	-	-	-	-	-	-	-	-	0.1	-	-	1.4
ROTIFERS	0.3	0.1	-	0.3	-	-	-	-	-	0.1	-	4.5	2.2	3.6	-	-	-	-	-	-	-	-	0.1	-	-	1.4
SAND AND MUD	2.8	9.3	7.6	17.1	35.6	38.7	46.1	37.0	55.0	46.2	49.3	23.6	8.8	9.3	28.0	5.2	2.8	26.3	30.2	44.9	36.7	61.0	42.5	25.0	3.8	27.7

TABLE - 19

VARIATIONS IN THE FOOD COMPOSITION OF LABEO BATA IN RELATION TO SIZE

FOOD ITEMS	SIZE GROUPS				
	II (201-250)	III (251-300)	IV (301-350)	V (351-400)	VI (401-450)
Green algae	14.4	14.5	15.8	15.2	15.6
Diatoma	30.4	30.5	15.5	10.3	6.4
Blue green algae	0.5	0.7	0.5	0.3	0.6
Desmids	1.1	1.2	2.8	-	-
Phytoflagellates	0.9	0.5	0.2	-	-
Algal spores and zygotes	1.7	1.1	2.4	2.7	2.9
Macrovegetation	1.6	1.9	2.0	3.3	3.0
Decayed organic matter	12.5	12.6	9.7	10.8	13.5
Rotifers	0.2	-	-	-	-
Sand and Mud	37.8	36.8	57.1	57.4	57.8

TABLE 20

PERCENTAGE OF DIFFERENT FOOD ITEMS IN THE GUT CONTENTS (ri) IN THE ENVIROMMENT (pi) AND ELECTIVITY INDEX (E) OF *L. BATA*

Food items	Fingerlings			Adults		
	% in gut contents (ri)	% in environment (pi)	Electivity index (E)	% in gut contents (ri)	% in environment (pi)	Electivity index (E)
Oedogonium	-	2.9	-1.0000	3.8	2.9	0.1343
Pediastrum	2.0	3.0	-0.2000	3.4	3.0	0.0625
Selenastrum	1.0	1.4	-0.1666	2.4	1.4	0.2631
Ankistrodesmus	-	2.0	-1.0000	3.0	2.0	0.2000
Scenedesmus	1.8	2.8	-0.2073	4.0	2.8	0.1764
Spirogyra	1.2	3.9	-0.6585	2.8	3.9	-0.1641
Tetraspora	-	1.5	-1.0000	7.0	1.5	0.6470
Crucigenia	-	1.0	-1.0000	4.1	1.0	0.6078
GREEN ALGAE	6.0	18.5	-0.5102	30.8	18.5	0.2494
Cyclotella	2.5	1.2	0.3512	2.7	1.2	0.3846
Diatoma	2.2	1.0	0.3750	2.0	1.0	0.3333
Nitzschia	0.7	0.9	-0.1250	0.6	0.9	-0.2000
Navicula	3.5	2.6	0.1475	3.9	2.6	0.1733
Cymbella	0.5	1.1	-0.8750	1.8	1.1	0.2413
Gyrosigma	-	0.6	-1.0000	0.6	0.6	-
Cocconeis	0.5	0.6	-0.0909	0.7	0.6	0.0769
Synedra	0.7	1.1	-0.2222	1.2	1.1	0.0434
Surirella	-	0.9	-1.0000	1.0	0.9	0.0526
DIATOMA	10.6	10.0	0.0291	14.5	10.0	0.1836
Nostoc	-	1.4	-1.0000	1.6	1.4	0.0666
Anabaena	0.1	2.1	-0.9090	0.8	2.1	-0.4482
Microcystis	-	3.0	-1.0000	2.7	3.0	-0.0526
Phormidium	1.0	2.8	-0.4736	2.0	2.8	-0.1666
BLUE GREEN ALGAE	1.1	9.3	-0.7961	7.1	9.3	-0.1341
Cosmarium	3.9	0.6	0.7333	1.8	0.6	0.5000
Closterium	7.5	3.8	0.3274	2.2	3.8	-0.2666
DESMIDS	11.4	4.4	0.4545	4.0	4.4	-0.0476
Volvox	2.7	3.9	-0.1818	2.0	3.9	-0.3220
Euglena	6.0	4.2	0.1764	2.9	4.2	-0.1830
PHYTOFLAGELLATES	8.7	9.1	-0.0224	4.9	9.1	-0.3000
ALGAL SPORES & ZYGOTES	11.5	6.5	0.2777	9.3	6.5	0.1772
Arcella	5.1	8.4	-0.2444	2.9	8.4	-0.4867
PROTOZOAN	5.1	8.4	-0.2444	2.9	8.4	-0.4867
Keratella	10.1	13.5	-0.1440	2.3	13.5	-0.7225
Brachionus	9.0	6.6	0.1538	0.3	6.6	-0.9130
ROTIFERS	19.1	20.1	-0.0255	2.6	20.1	-0.7709
Cyclops	17.5	7.9	0.3779	0.9	7.9	-0.7954
Daphnia	9.0	5.8	0.2162	1.2	5.8	-0.6571
CRUSTACEANS	26.5	13.7	0.3366	2.1	13.7	-0.7341

TABLE - 21

SEASONAL VARIATIONS IN THE INTENSITY OF FEEDING OF L. BATA

Months	MALE		FEMALE	
	G.S.I.	% empty guts	G.S.I.	% empty guts
Oct. 1972	9.1	-	9.7	-
Nov.	8.0	-	9.3	-
Dec.	6.2	-	6.8	-
Jan. 1973	4.6	12.7	4.5	18.1
Febr.	5.8	57.1	4.9	37.5
March	5.6	55.5	5.1	14.2
April	4.8	66.6	4.5	-
May	4.2	71.4	2.7	53.3
June	2.6	100.0	1.2	42.8
July	1.9	100.0	0.9	86.6
August	1.5	100.0	1.0	99.9
Sept.	-	-	6.1	33.3
Oct.	1.1	40.0	1.1	16.6
Nov.	4.7	-	7.3	20.0
Dec.	9.3	-	9.7	-
Jan. 1974	5.5	-	5.1	-
Febr.	3.6	-	5.5	50.0
March	7.3	51.5	9.5	32.5
April	4.5	20.0	3.9	40.0
May	4.1	45.5	4.2	37.0
June	3.8	46.6	3.5	33.3
July	2.2	55.5	1.4	100.0
August	8.7	10.5	9.5	9.0
Sept.	-	-	-	-
Oct.	5.5	5.0	6.3	4.0

TABLE - 22

VARIATIONS IN THE INTENSITY OF FEEDING WITH SIZE

Size group (mm)		Gastro-somatic index	% empty guts
I	150-200	10.95	10.00
II	201-250	3.49	25.86
III	251-300	4.93	22.03
IV	301-350	4.74	22.41
V	351-400	3.87	36.00
VI	401-450	2.74	37.50

TABLE - 23

VARIATIONS IN THE INTENSITY OF FEEDING WITH MATURITY STAGES

Maturity stages	Sex	Gastro-somatic index	% empty guts
I	Male	4.80	6.81
	Female	5.49	5.45
II	Male	5.54	-
	Female	6.12	8.33
III	Male	4.52	12.19
	Female	4.76	5.71
IV	Male	5.55	55.26
	Female	1.90	75.92
V	Male	5.44	40.00
	Female	4.51	37.50

CHAPTER VI

REPRODUCTION

INTRODUCTION

The knowledge of reproductive biology of a fish is extremely important in successful management and exploitation of its fishery. In a biosphere, the success and failure of a species, largely depends on its spawning potential. Indian carps normally breed in monsoon months when the rivers are flooded. Several workers attempted induced spawning in these fishes by the injection of pituitary extracts (Khan, 1938; Chaudhry and Alikunhi, 1951; Chaudhury, 1960, 1963; Jhingran, 1969; Chondar, 1970 and Anand, 1973).

Labeo bata (Ham.) is one of the important freshwater carp of India. Inspite of being an important fish, no account is available on the reproductive biology of this species. However, some informations are available on various aspects of the reproductive biology of carps and other freshwater fishes (Khan, 1924, 1942; Hora, 1945; Mazumdar, 1945; Mookerjee, 1945; Alikunhi, 1953, 1956; Khanna, 1957; Jhingran, 1961; Qayyum and Qasim, 1961; Chakrabarty and Singh, 1963; Natarajan and Jhingran, 1963; Parameswaran *et al*. 1970 and Khan, 1972).

The present study deals with the sex ratio, spawning season, seasonal cycle in gonad condition, gono-somatic index, size frequency distribution of mature oocyte during different months and fecundity.

MATERIALS AND METHODS

Samples for the present investigation were obtained from the river Kali, a tributary of the river Ganga, with the help of cast nets and drag nets in the first week of each month. A total of 340 females and 235 males of different sizes were examined over a period of 13 months, from October, 1972 to October, 1973.

After recording the length, weight, and age of the fish, the gonads were taken out and their stage of maturation was assessed. Sex ratio in relation to size, season and age was determined, using Chi-square analysis. The null hypothesis of no significant deviation from a 1:1 sex ratio was tested in monthly samples and in fish belonging to different age groups. Size and age at first maturity as well as the size at which 50% and above fish were mature was also determined. Seasonal changes in gonad condition and gono-somatic index (gonad weight as percentage of body weight) were followed to determine spawning behaviour and extent of breeding season. The size progression of intra-ovarian oocytes was followed from March to August. A portion of the preserved (5% formalin) ovary was teased apart, and all the oocytes (500 to 1000) were measured with an occular micrometer.

Fecundity was estimated by gravimetric method. After weighing the two ovaries on a Sartorius single pan balance to within 0.001 g, two small portions of the ovary (approximately

500 eggs) were taken, accurately weighed and then all the eggs were counted. A mean of the two counts was noted and then multiplied by the total weight of the ovary. Fecundity, total length of the fish, body weight, ovary weight and age were examined by regression analysis.

RESULTS

Sex ratio

Of 578 specimens, 238 were males and 340 were females (Table 24) giving a ratio of 1:1.42, which did not deviate significantly from the hypothetical distribution of 1:1. A Chi-square test of homogeneity based on combined data confirmed it. There was no definite pattern of preponderance of any sex during different months of the year. However, sex composition was related to size (Table 26) and age (Table 25). For example, a significant preponderance of males over females was recorded in age group 0, thereafter, the females outnumbered the males. In age groups VI and VII no males were recorded.

Stages of maturity and size and age at first maturity

The gonads of L. bata were classified into five maturation stages according to size, shape and colour:

(I) immature; (II) maturing virgins or recovered spents;
(III) ripening; (IV) ripe; (V) spent.

The smallest ripe male recorded was 18 cm and the smallest female 19 cm in length and 50% of both sexes were ripe when the fish were 20 cm long (Table 26).

Both sexes attained sexual maturity when they were about one year old.

Spawning cycle

The gonads showed a regular seasonal development with little overlap between different maturation stages (Fig. 25). Fish with ripening gonads first appeared in March and became predominant in April and May. In late May and early June both sexes were fully ripe. In late July spent fish appeared, their percentage increased in August and by September all fish became spent. The progressive increase of spent fish in August and September and the total absence of ripe fish in September indicates that the spawning is restricted to July and August.

Spawning periodicity and spawning behaviour

Ova diameter frequencies of L. bata indicate that the ovaries contain a single batch of ova, clearly separated from the immature stock (Fig. 26).

The maturation of ova began in March when the average size of ova was 0.22 mm. In April the modal size of ova reached to 0.60 mm rising to 1.00 mm in May and to 1.30 in June. In late July this ova size class was lacking in the ovaries of a few individuals, but by September all fish lacked this ova size class. Thus it is evident that each individual spawns only once in a breeding season which is restricted to a short period (July and August).

In 1973 the onset of the monsoon took place in mid-July, followed by river flooding and high current velocity down-stream. Ripe fish, most probably stimulated by the strength of the current, migrated upstream and selected a suitable spawning ground in the adjoining inundated shallow areas where the velocity of water current was very low. Here both sexes congregated and spawning took place. After spawning the fish moved into deeper waters. Females formed 65.1% of the spawning population. Successful spawning then depends upon the availability of suitable spawning ground which is inturn controlled by the extent of the monsoon.

Gono-somatic index

Seasonal variations in the gono-somatic indices of both sexes were quite apparent (Fig. 27) and although similar patterns were obtained, a more well-defined pattern occurred in females. Maximum values were recorded in June with a slight decrease in July, a considerable drop in August and minimum levels in September. Thereafter, the indices remained almost constant till February. From March onwards the values increased reaching maximum levels again in June.

These cyclic changes in gono-somatic indices are further proof that the spawning season is quite short lasting only two months in July and August.

Fecundity

Fecundity estimates are based on 60 mature female individuals caught in June and July. Fecundity varied considerably from individual to individual and ranged from 10,040 to 870,000 with an average of 192,785. Number of ova per mm body length, per g body weight and per g ovary weight were 517, 584 and 1078 respectively.

Fecundity and length of the fish

The relationship between the fecundity and length of the fish was found to be parabolic (Fig. 28) i.e., $F = aL^n$, and the fecundity could be related to body length by the equation:

$$F = -2.814 + 5.8202 \log L \ (L = \text{length}) \ (r = .87)$$

Fecundity and body weight

The relationship of fecundity to body weight was found to be linear (Fig. 29), and could be expressed by the following equation:

$$F = 1.3938 + 1.6499 \log W \ (W = \text{body weight}) \ (r = .88)$$

Fecundity and ovary weight

A linear relationship was obtained between the fecundity and ovary weight (Fig. 30). The regression equation for this relationship is:

$$F = 3.1455 + 1.0184 \log O.W. \text{ (OW = ovary weight) } (r = .92)$$

Fecundity and age

A linear relationship was also obtained between fecundity and age (Fig. 31). The regression equation for this relationship is :

$$F = -2.2630 + 5.7399 \log A \text{ (A = age) } (r = .85)$$

DISCUSSION

This study of cyclic changes in the maturation and depletion of gonads, intra-ovarian oocytes, and gono-somatic index clearly indicates a synchronous breeding in *L. bata*. The breeding season is short and lasts for two months. This is generally characteristic of those fish species which contain only one group of eggs in the ovary (Prabhu, 1956; Dharmamba, 1959; Qasim and Qayyum, 1962). Spawning in other cyprinid fishes in Northern India is restricted to July and August (Khan, 1924, 1942; Qasim and Qayyum, 1961; Khan, 1972). In this respect, *L. bata* does not differ from other cyprinids.

Seasonal changes in the gonadal condition are well-marked. The recovering gonads (stage II) remained quiescent from October to January, coinciding with the minimal solar radiation and temperature during this period (Fig. 32). In February a slight development of gonads was noted, but, thereafter, rapid changes occurred and in both sexes the peak condition was reached in June. During this period the photoperiod and temperature were maximum, it was evident therefore that the cyclic development of gonads is influenced by photoperiod and temperature. Aronson (1957), Pickford and Atz (1957) and Hyder (1970) have also reported the importance of both light and temperature in gonadal development of fishes.

The onset of spawning, its success, and the duration of breeding season appear to be directly dependent on the monsoon. In Northern India, the monsoon generally breaks out in July and continues upto August. Spawning is also restricted to these two months. On the other hand in the Eastern India, the onset of monsoon is early and continues upto August, consequently the breeding season lasts from April to August (David, 1959). In Chittagong region the breeding season of major carps extends from April to June (Ahmad, 1948).

The success of spawning depends upon access to a suitable spawning ground, usually the inundated areas adjoining the river where the current is only of moderate strength. When such flooded conditions exist an extensive area for spawning is available.

Gravid fishes migrate in these shallow waters where peak spawning occurs without any competition for space. This has been confirmed by the observations of Khanna (1958) who successfully induced spawning in carps by artificially flooding a stocking pond. Generally, temperatures are uniform and moderately high during the monsoon (July and August) and this further influences spawning.

Sex ratio between males and females did not deviate significantly from the hypothetical distribution of 1:1. In other carps, e.g., Cirrhina mrigala, Catla catla and Labeo rohita no significant deviation from 1:1 sex ratio was recorded by Chakarbarty and Singh (1963), Natarajan and Jhingran (1963) and Khan (1972) respectively. Males were numerous in smaller size groups whereas females were predominant in larger size groups. The preponderance of females in larger size groups appears to be due to heavy mortality of males in the smaller size groups. At that stage they are more active and thus more liable to be caught by fishermen or more exposed to predation.

Males matured earlier than the females, and also attained maturity at a smaller size. Both these characteristics of males appear to be related to a more active, shorter life. The recovered spents of both sexes matured earlier than the maturing virgins.

The size of mature ova did not vary in fish of different sizes as reported earlier in other cyprinid fishes (Khan, 1972).

However, Simpson (1951) and Wydoski and Cooper (1966) reported variations in the size of mature ova in plaice and brook trout.

Fecundity of L. bata increased at a rate of 5.8202 of the length. This indicates that the increase in fecundity is more rapid than the cube of the length. Higher rates of increase in fecundity in relation to length have been reported in Irish herring (Farran, 1938), North Sea herring (Hickling, 1940) and in two small sized freshwater fish species, Callichrous bimaculatus, Mystus vittatus (Qasim and Qayyum, 1963). The relationship between fecundity and length of L. bata was non-linear as reported in a number of fish species (Raitt, 1933; Hickling, 1940; Allen, 1951; Simpson, 1951; Bagenal, 1957; Qasim and Qayyum, 1963) and either the fecundity had been found to be related to the square of the length (Franz, 1910; Kisselevitch, 1923; Clark, 1934) or to the cube of the length (Simpson, 1951; Pillay, 1958; Khan, 1972).

Fecundity continued to increase with age while growth in length became extremely slow. This explains maximum fecundity in fish of the oldest age group. The linear relationship between fecundity, body weight and ovary weight indicated that in L. bata the number of eggs in the ovaries increased in proportion to these two variables.

SUMMARY

In the river Kali, the population of L. bata showed a male : female sex ratio of 1:1.42. Males matured at length of 18 cm and females at 19 cm. 50% of both sexes were mature at 20 cm size. Maturity was attained when both sexes were about one year old.

Spawning occurs during July and August, the period of maximum precipitation and uniformly high temperatures. Each individual contained only one stock of oocytes and spawned only once in a breeding season. The success of spawning depends upon the access of gravid fish to suitable spawning ground.

Individual fecundity varied from 10,040 to 870,000 with an average of 192,785. Fecundity was found to be more closely related to ovary or body weight than length.

Fig. 25. Percentage of _L_. _bata_ at each of the five stages of maturation.

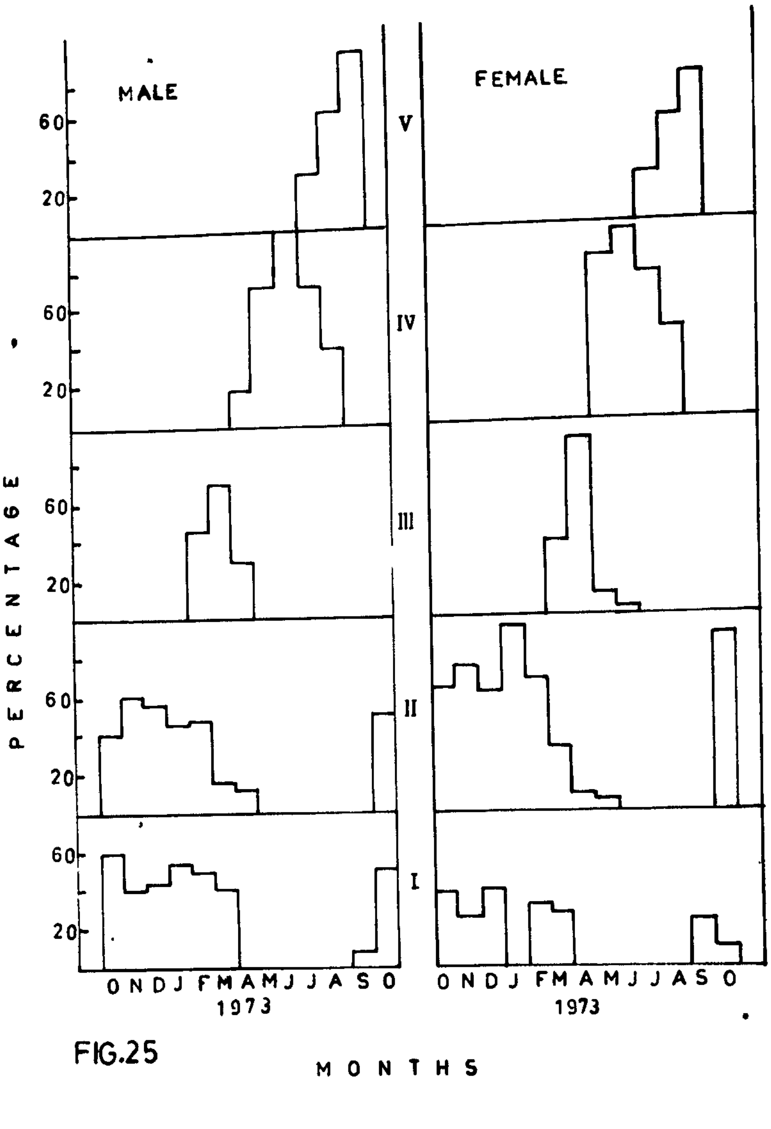

MALE
FEMALE
V
IV
III
II
I
60
20
PERCENTAGE
O N D J F M A M J J A S O
1973
O N D J F M A M J J A S O
1973
MONTHS

FIG.25

Fig. 26. Size frequency distribution of intra-ovarian oocytes of *L. bata*.

Fig. 27. Seasonal variation in gono-somatic index of *L. bata*.

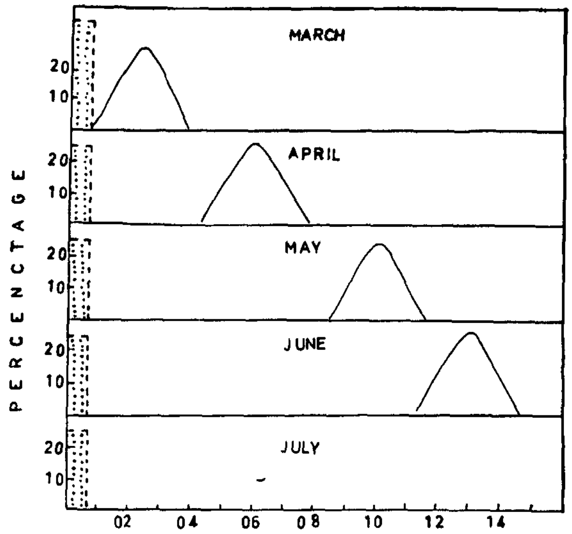


FIG.26 OVA.DIAMETER (MM)

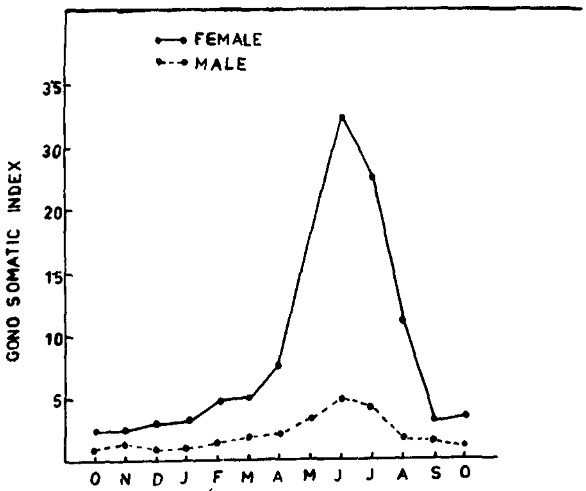


FIG.27

Fig. 28. Scatter diagram showing the relationship between fecundity and length.

Fig. 29. Scatter diagram showing the relationship between fecundity and body weight.

Fig. 30. Scatter diagram showing the relationship between fecundity and ovary weight.

Fig. 31. Relationship between fecundity and age.

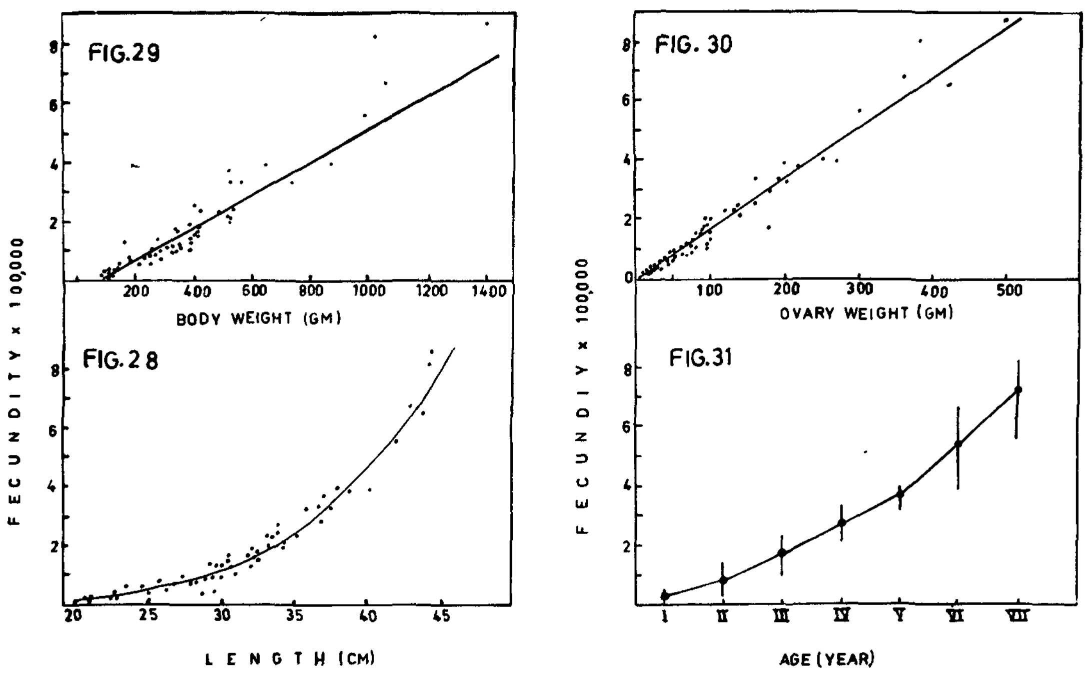


FIG.29
BODY WEIGHT (GM)
FIG.28
LENGTH (CM)
FECUNDITY x 100,000
FIG. 30
OVARY WEIGHT (GM)
FIG.31
AGE (YEAR)
FECUNDITY x 100,000

Fig. 32. Seasonal variations in temperature and rainfall at Aligarh.

TABLE - 24

NUMBER OF MALES AND FEMALES IN DIFFERENT MONTHS SAMPLES

Months	No. of males	No. of females	Sex ratio
Oct. 1972	15	16	1:1.10
Nov.	20	24	1:1.20
Dec.	16	20	1:1.25
Jan. 1973	24	33	1:1.37
Feb.	21	24	1:1.14
Mar.	27	21	1:0.77
Apr.	16	12	1:0.75
May	14	30	1:2.14
June	16	29	1:1.81
July	24	56	1:2.33
Aug.	13	24	1:1.84
Sept.	12	30	1:2.50
Oct.	20	21	1:1.05
Total	238	340	1:1.42

TABLE - 25

NUMBER OF MALES AND FEMALES IN VARIOUS AGE GROUPS

Age groups	No. of males	No. of females	Sex ratio
0	74	54	1:0.73
1+	71	88	1:1.24
II	52	85	1:1.63
III	25	40	1:1.60
IV	13	31	1:2.38
V	3	22	1:7.33
VI	-	13	-
VII	-	7	-
Total	238	340	1:1.42

TABLE 26

MATURITY STAGES IN DIFFERENT LENGTH GROUPS OF <u>L. BATA</u>

Length (cm)			7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
MATURITY STAGES	MALE	I	10	9	7	6	10	8	5	4	6	4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		II	-	-	-	-	-	-	-	-	-	1	3	4	3	2	3	4	3	7	4	7	4	3	3	1	2	3	1	1	2	1	-	-	-	-	-	-	-	-
		III	-	-	-	-	-	-	-	-	-	-	-	5	3	1	1	2	4	2	2	2	2	1	3	2	1	2	1	1	1	1	-	-	-	-	-	-	-	-
		IV	-	-	-	-	-	-	-	-	-	-	-	2	4	6	3	4	2	3	3	2	2	2	3	2	5	2	2	3	-	-	1	-	-	-	-	-	-	-
		V	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	2	1	1	2	1	1	2	3	3	1	1	1	-	-	-	-	-	-	-	-	-	-	-
	FEMALE	I	7	8	5	3	6	2	3	4	3	4	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		II	-	-	-	-	-	-	-	-	-	-	1	5	6	6	5	4	6	7	6	8	4	6	4	5	6	2	3	3	3	2	3	2	2	2	1	1	1	1
		III	-	-	-	-	-	-	-	-	-	-	-	2	4	2	2	1	1	4	1	3	3	2	2	1	2	1	1	1	1	1	1	1	1	1	-	-	-	-
		IV	-	-	-	-	-	-	-	-	-	-	-	-	2	6	8	5	3	5	7	5	5	9	7	5	6	6	4	4	5	2	3	3	1	2	1	1	1	-
		V	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	2	3	2	2	3	3	4	2	2	3	1	1	2	3	2	1	1	1	1	-	-	-	2

PART II

THE BIOLOGY OF *LABEO GONIUS* (HAM.)

CHAPTER VII

MORPHOMETRIC STUDIES, LENGTH-WEIGHT RELATIONSHIPS AND RELATIVE CONDITION FACTOR.

INTRODUCTION

Inspite of widespread distribution of *Labeo gonius* (Ham.) in India and its importance, there is no published data on its biology. This paucity of knowledge has promoted initiation of detailed studies on the biology of the species in river Kali, which is a major source of fish supply at Aligarh.

The present study was undertaken to provide a detailed account of morphometry, length-weight relationship and relative condition factor of this species.

MATERIALS AND METHODS

Samples of *L. gonius* were obtained along with *L. bata* during the same period of study, from the river Kali. The methods used for morphometric studies, length-weight relationships and relative condition factor of the fish are the same as described for *L. bata* (Page 9, 14 and 22).

RESULTS AND DISCUSSION

MORPHOMETRIC STUDIES:

Morphometric studies of *L. gonius* obtained from the environments (river Kali and pond Chau Tal) were made to identify separate stocks of this species.

Straight line relationships between different body measurements and total lengths were obtained in fishes of the river Kali and pond Chau Tal (Figs. 33 and 35). The regression equations describing these relationships are given in tables 27-30. Mean relative measurements of different body characters expressed as percent of total length along with their range and standard deviation are plotted in Fig. 34 (riverine fishes) and Fig. 36 (Chau Tal fishes). When comparing the mean lengths of fishes from the two different environments it was found that the mean standard length differed more significantly than the body length, as in the case of L. bata. The mean depth measurements also showed the same pattern as in L. bata.

A significant difference was noted between the fishes of river Kali and pond Chau Tal. The characters associated with length were higher in case of pond fishes while the characters associated with depth were higher in riverine fishes than the pond fishes.

LENGTH-WEIGHT RELATIONSHIPS:

The regression analysis of length-weight relationship along with the test of significance have been presented in Table 31. The analysis of covariance for data of Table 31 is summarised in Table 32. The 'n' values ranged from 2.1975 (gutted females) to 3.0981 (ripe females) and 2.3693 (gutted males) to 3.1010 (ripe males). The value of 'n' was found to be highest in juveniles (3.1322) while lowest in females (3.0981). The 'n' values calculated at 95% confidence intervals for male, female and juvenile, were always higher than 3 (Table 33). Obviously the length-weight relationship of this fish did not follow the cube law.

The length-weight relationships of males, females and juveniles are represented in Table 33 and Fig. 37. Fig. 38 shows the length-weight relationship of combined fishes. The smooth curve represents the calculated weight at each length intervals while straight line represents the calculated regression. Average weights at different lengths intervals are also tabulated (Table 34). From this table it may be seen that the increase in weight in relation to length was not well marked upto 150 mm length. It was conspicuous between 150-200 mm and well appreciable above 200 mm. It was noted that females were lighter than males upto the length of 245 mm but the males were lighter than females at higher lengths and the length-weight curves of two sexes intersected at a point between 245 mm and 265 mm (Fig. 37).

In L. rohita some differences in the values of 'n' of fishes from rivers and pond have been reported (Khan, 1972). The riverine fishes were heavier than pond fishes at a particular length, indicating more growth in rivers than in the pond. It appears that metabolities are washed down in the running water and this leads to a better growth. When 'n' was compared in fishes at different maturity stages, it was found that the value of 'n' was highest in ripe fishes and lowest in spent fishes. It is mainly due to considerable development of gonads which affect the total weight of the fish.

RELATIVE CONDITION FACTOR:

Variations in 'Kn' values in relation to size are quite apparent (Fig. 39). The value was found to be highest in smaller fishes of both the sexes. High values were obtained upto 210 mm in males and 230 mm in females. Thereafter, the 'Kn' values decreased and increased alternately upto the length of 450 mm and 3 peaks and 3 valleys were found i.e. at the length of 310 mm, 370 mm and 430 mm in females and 230 mm, 330 mm and 390 mm in males (Table 35, Fig. 40).

Fluctuations in relative condition in relation to size appear to be influenced by the number of spawnings that have taken place in six to seven years of life. In that event the fish appears to have spawned 3 to 4 times over the span of life and this is quite true because the fish attains sexual maturity when it is about 2 years old and thereafter spawns successively and annually (Siddiqui et al., 1976).

Seasonal fluctuations in relative condition can be seen in Fig. 40. Low values were obtained in December and January thereafter it increased and attained maximum level in June. Another peak was also noted in November. Lowest relative condition values were recorded in September, July and August (Table 36, Fig. 40).

There was a sharp increase in condition with gonads from April to June while the condition minus gonads in females decreased considerably. The decrease in condition with gonads during July and August was also very clear and the condition minus gonad did not show any significant decrease. No difference between condition with gonads and condition minus gonads was observed during rest of the year. Similar trend was observed for males. Gastro-somatic index was found to decrease significantly from April to July in females. During rest of the months the gastro-somatic indices were found to increase gradually in both the sexes (Table 37, Figs. 41 and 42).

Seasonal fluctuations in the relative condition are mainly due to maturation and depletion of gonads. Highest values were recorded when the fish were in ripe condition and lowest just after spawning. Similar observations have been made in majority of fish species which are seasonal breeders, but evidences available showing the seasonal fluctuations brought about by feeding rhythm (Qasim, 1957; Bal and Jones, 1960; Blackburn, 1960 and Bhatt, 1971).

SUMMARY

Morphometric studies on L. gonius revealed that significant differences existed between fishes from two different environments (river Kali and pond Chau Tal). However, the differences between the fishes of different years or sexes were not statistically significant. The equations for LW relationship are $W = 0.8066 \times 10^{-5} L^{3.1010}$ for the male, $W = 0.5635 \times 10^{-5} L^{3.0981}$ for the female, $W = 0.7995 \times 10^{-5} L^{3.1322}$ for the juvenile and $W = 0.1512 \times 10^{-5} L^{3.7794}$ for the combined fishes. The two LW curves intersected at a point between 245 and 265 mm. The 'Kn' value was found to be high in smaller fishes (190 to 230 mm), thereafter it decreased and increased several times. These peaks indicate the number of spawnings upto this length. Seasonal fluctuations in the condition are due to fluctuation in the gonad weights. High values coincide with the breeding season.

FIG.33

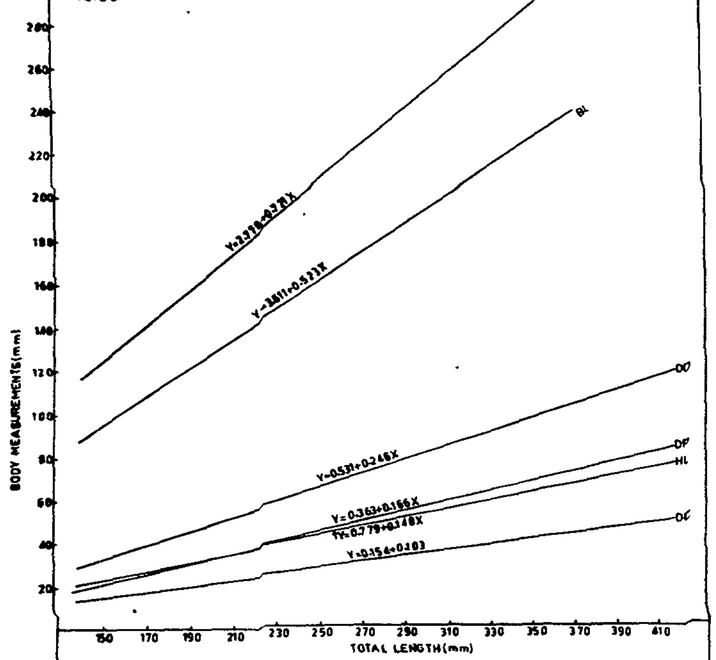


FIG.34

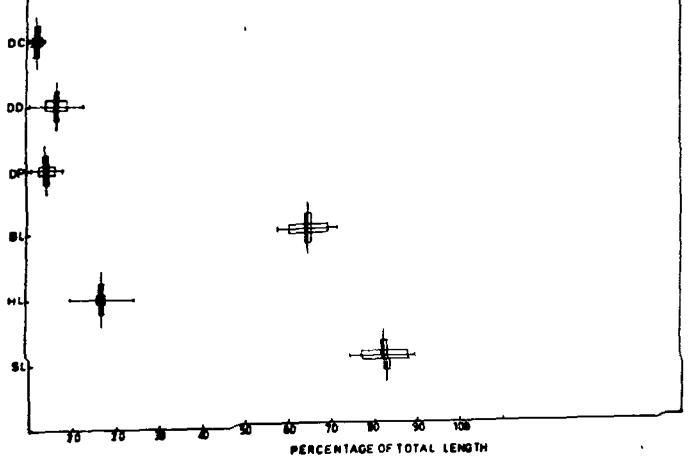


FIG.35

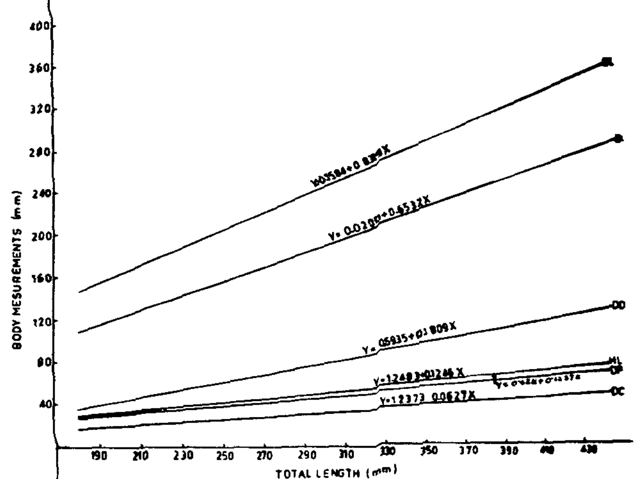


FIG.36

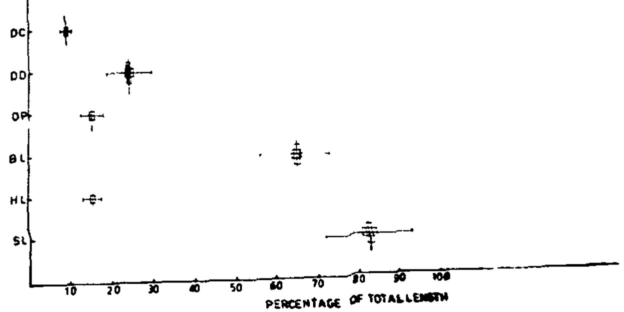


Fig. 37. The length-weight relationships of males, females and juveniles of *L. gonius*.

Fig. 38. The length-weight relationship of combined *L. gonius*.

(The straight line represents the calculated regression line of log weight on log length and the smooth curve represents the calculated weight).

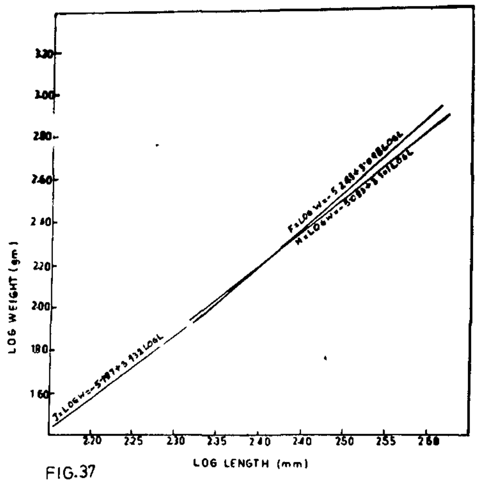


FIG. 37

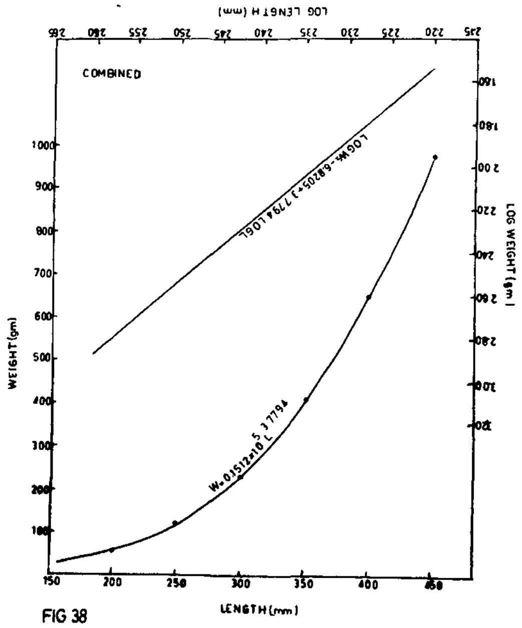


FIG 38

Fig. 39. Mean 'Kn' values at different size groups of *L. gonius*.

Fig. 40. Monthly variations in mean 'Kn' values of *L. gonius*.

Fig. 41. Seasonal fluctuations in 'Condition with gonad', 'Condition minus gonad' and 'Condition minus gonad plus gut' of *L. gonius*. (Males)

Fig. 42. Seasonal fluctuations in 'Condition with gonad', 'Condition minus gonad' and 'Condition minus gonad plus gut' of *L. gonius*. (Females)

(The upper curves represent the 'Condition with gonad', the middle 'Condition minus gonad' and the lower 'Condition minus gonad plus gut'. The area enclosed by upper and middle curves represents the gonado-somatic index and by the middle and lower curves represents the gastro-somatic index).

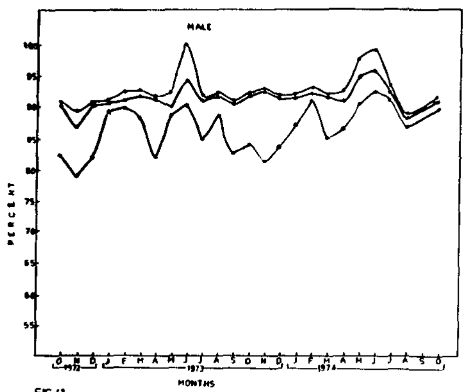


FIG.41

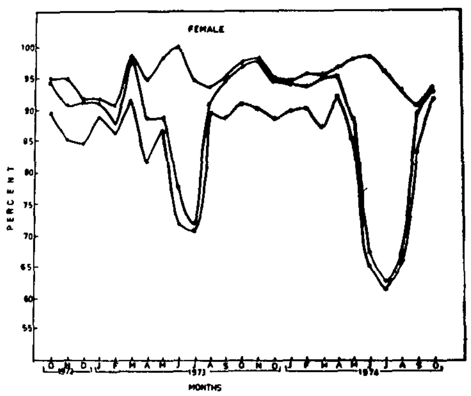


FIG.42

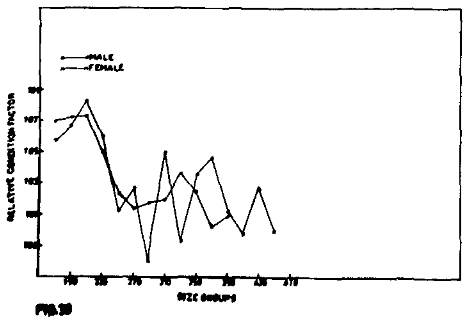


FIG.39

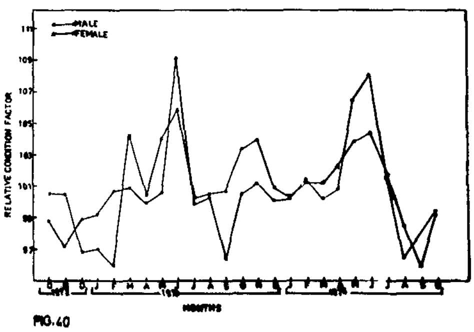


FIG.40

TABLE 27

STATISTICS OF REGRESSION OF DIFFERENT BODY MEASUREMENTS ON TOTAL LENGTH OF L. GONIUS

Character	MALE				FEMALE				COMBINED			
	Regression coefficient	S.S. due to regression	Residual S.S.	D.F.	Regression coefficient	S.S. due to regression	Residual S.S.	D.F.	Regression coefficient	S.S. due to regression	Residual S.S.	D.F.
Standard length	0.802	1341.184	127.946	36	0.770	3601.878	59.557	66	0.721	514.650	70.000	102
Head length	0.206	137.301	96.114	36	0.161	302.675	11.707	66	0.148	455.584	13.202	102
Body length	0.540	524.125	94.500	36	0.610	3214.152	9.833	66	0.523	418.568	169.301	102
Depth through pectoral fin base	0.223	172.223	25.310	36	0.169	278.865	14.088	66	0.166	466.970	12.090	102
Depth through dorsal fin base	0.301	131.737	15.175	36	0.255	222.576	19.716	66	0.246	371.855	21.602	102
Depth of the caudal peduncle	0.125	222.266	7.535	36	0.112	140.886	27.885	66	0.103	280.820	30.705	102

TABLE 28

EQUATIONS OF THE REGRESSION OF DIFFERENT BODY MEASUREMENTS ON TOTAL LENGTH OF *L. GONIUS*

(RIVERINE FISHES)

Character	Mean total length (cm) ($\bar{x}$)	Mean length of body measurements (cm) ($\bar{y}$)	Regression equation $y = a + b x$	Percent of total length
		MALE		
Standard length	26.4	21.7	$y = 0.522 + 0.802 x$	82.19
Head length	26.4	4.5	$y = 0.798 + 0.206 x$	17.04
Body length	26.4	17.0	$y = 2.748 + 0.540 x$	64.39
Depth through pectoral fin base	26.4	4.8	$y = -1.085 + 0.223 x$	18.18
Depth through dorsal fin base	26.4	6.8	$y = -1.157 + 0.301 x$	25.75
Depth of the caudal peduncle	26.4	2.8	$y = -0.441 + 0.125 x$	10.60
		FEMALE		
Standard length	29.4	24.1	$y = 3.742 + 0.690 x$	81.97
Head length	29.4	5.2	$y = 1.483 + 0.126 x$	17.68
Body length	29.4	19.2	$y = 2.175 + 0.579 x$	65.30
Depth through pectoral fin base	29.4	5.2	$y = 0.869 + 0.148 x$	17.68
Depth through dorsal fin base	29.4	7.9	$y = 1.406 + 0.221 x$	26.87
Depth of the caudal peduncle	29.4	3.2	$y = 0.399 + 0.095 x$	10.88
		COMBINED		
Standard length	27.9	22.9	$y = 2.770 + 0.721 x$	82.07
Head length	27.9	4.8	$y = 0.799 + 0.148 x$	17.20
Body length	27.9	18.1	$y = 3.611 + 0.523 x$	64.87
Depth through pectoral fin base	27.9	5.0	$y = 0.363 + 0.166 x$	17.92
Depth through dorsal fin base	27.9	7.3	$y = 0.531 + 0.246 x$	26.16
Depth of the caudal peduncle	27.9	3.0	$y = 0.154 + 0.103 x$	10.75

TABLE 29

STATISTICS OF REGRESSION OF DIFFERENT BODY MEASUREMENTS ON TOTAL LENGTH OF *L. GONIUS*

(CHAU TAL)

Character	Regression coefficient (b)	S.S. due to regression	Residual S.S.	D.F.
	(Combined fishes)			
Standard length	0.8319	2216.4738	123.5037	155
Head length	0.1246	1765.2030	57.4774	155
Body length	0.6532	2282.6892	57.2883	155
Depth through pectoral fin base	0.1237	2608.4564	268.4789	155
Depth through dorsal fin base	0.1809	2159.6846	180.2929	155
Depth of the caudal peduncle	0.0627	568.8771	17.7110	155

D.F. = Degrees of freedom S.S. = Sum of squares

TABLE 30

EQUATIONS OF THE REGRESSION OF DIFFERENT BODY MEASUREMENTS ON TOTAL LENGTH OF *L. GONIUS*

(CHAU TAL)

Character	Mean total length (cm) ($\bar{x}$)	Mean length of body measurement (cm) ($\bar{y}$)	Regression equation $y = a + b x$	Percent of total length
		(Combined fishes)		
Standard length	29.8	24.7	$y = -0.1584 + 0.8319 x$	82.88
Head length	29.8	4.9	$y = 1.2483 + 0.1246 x$	16.44
Body length	29.8	19.5	$y = -0.0200 + 0.6532 x$	65.43
Depth through pectoral fin base	29.8	4.8	$y = -0.6211 + 0.1237 x$	16.10
Depth through dorsal fin base	29.8	7.4	$y = 0.5935 + 0.1809 x$	24.83
Depth of the caudal peduncle	29.8	3.0	$y = 1.2373 + 0.0627 x$	10.06

TABLE 31

STATISTICS OF REGRESSION OF LOG WEIGHT ON LOG LENGTH OF L. GONIUS

Source	Regression coefficient 'b'	S.S. due to regression	Residual S.S.	D.F.	Correlation coefficient 'r'	Observed 'T'	5% t	Significance
Male	3.1010	38.3750	3.6945	59	0.0375	2.0997	2.001	S
Female	3.0981	24.3953	3.8283	119	0.2669	1.9951	1.981	S
Juvenile	3.1322	26.3333	3.0166	13	0.5831	2.4861	2.160	S
Maturity stage I Male	3.0030	1.3440	0.1633	18	0.6719	1.7403	2.101	NS
Maturity stage I Female	3.0547	0.6868	0.0334	29	0.0815	0.4399	2.045	NS
Maturity stage II Male	3.1568	0.9215	0.0385	8	0.2018	0.5396	2.306	NS
Maturity stage II Female	3.0677	1.1559	0.0501	20	0.7704	1.5265	2.086	NS
Maturity stage III Male	3.0140	1.1689	0.0627	11	0.0980	0.3408	2.201	NS
Maturity stage III Female	3.3744	1.5398	0.0300	17	0.4400	1.0831	2.110	NS
Maturity stage IV Male	3.6112	0 0.4898	0.0347	12	0.6441	1.7929	2.179	NS
Maturity stage IV Female	3.6625	0.6592	0.0933	25	0.2608	1.3232	2.060	NS
Maturity stage V Male	3.0734	0.5328	0.0254	5	0.6084	1.5332	2.571	NS
Maturity stage V Female	3.0377	0.5774	0.0380	23	0.0785	0.3691	2.069	NS
Total within different maturity stages	3.0837	16.7605	7.9044	171	-	-	-	-
		DIFFERENCE	0.0307	10	-	-	-	-
Total between means of different maturity stages	3.1780	0.9038	0.0407	9	-	-	-	-
		TOTAL	7.9451	191	-	-	-	-
Combined (Male, Female and Juvenile)	3.7794	17.6643	7.9450	192	0.6316	11.2874	1.960	S
		DIFFERENCE	0.0001	1	-	-	-	-

S.S. = Sum of squares; D.F. = Degrees of freedom; N.S = Not significant; S = Significant

TABLE - 32

ANALYSIS OF VARIANCE FOR DATA IN TABLE 31

Source	Sums of square	D.F.	Variance
Due to total regression	17.6643	1	17.6643
Between regression coefficient within different maturity stages	0.0307	10	0.0030
Difference between pooled within different maturity stages and means regression	0.0001	1	0.0001
Deviation of means from means regression	0.0407	9	0.0045
Residual	7.9450	171	-
Total	25.6808	192	-

TABLE 33

REGRESSION EQUATIONS OF WEIGHT ON LENGTH OF <u>LABEO GONIUS</u> AND THEIR TEST OF SIGNIFICANCE

SOURCE	REGRESSION COEFFICIENT 'b'	INTERCEPT OF 'b'	VARIANCE OF 'b'	S.D. OF 'b'	S.E. OF 'b'	95% CONFIDENCE LIMIT OF 'b'	S.E. OF 'a'	REGRESSION EQUATION	PARABOLIC EQUATION
MALE	3.1010	-5.0934	0.0414	2.2034	0.02648	3.0492-3.1527	0.01738	$\text{Log } W = -5.0934 + 3.1010 \text{ Log } L$	$W = 0.8066 \times 10^{-5} L^{3.1010}$
FEMALE	3.0981	-5.0491	0.0288	0.1697	0.01549	3.0678-3.1284	0.00654	$\text{Log } W = -5.2491 + 3.0981 \text{ Log } L$	$W = 0.5635 \times 10^{-5} L^{3.0981}$
JUVENILE	3.1322	-5.1972	0.0259	0.1611	0.04305	3.0475-3.2169	0.01336	$\text{Log } W = -5.1972 + 3.1322 \text{ Log } L$	$W = 0.7995 \times 10^{-5} L^{3.1322}$
COMBINED	3.7794	-6.8205	0.0321	0.1792	0.01290	3.7541-3.8046	0.00673	$\text{Log } W = -6.8205 + 3.7794 \text{ Log } L$	$W = 0.1512 \times 10^{-5} L^{3.7794}$

S.D. STANDARD DEVIATION S.E. STANDARD ERROR

TABLE - 34

CALCULATED WEIGHT OF *L. GONIUS* AT DIFFERENT LENGTH INTERVALS

Total length (in mm)	Body weight (in gms)
150	27.87
200	58.20
250	123.40
300	228.10
350	400.80
400	640.10
450	927.70

TABLE - 35

MEAN 'Kn' VALUES OF L. GONIUS AT DIFFERENT SIZE GROUPS

Size groups	Mean 'Kn'	
	Male	Female
150 - 170	108.0	106.7
171 - 190	108.2	107.6
191 - 210	108.3	109.3
211 - 230	106.0	107.0
231 - 250	103.3	102.2
251 - 270	102.3	103.7
271 - 290	102.7	99.0
291 - 310	102.9	106.0
311 - 330	104.6	100.2
331 - 350	103.4	104.5
351 - 370	101.2	105.6
371 - 390	101.9	102.2
391 - 410	-	100.7
411 - 430	-	103.7
431 - 450	-	101.0

TABLE - 36

MONTHLY VARIATIONS IN MEAN 'Kn' VALUES OF *L. GONIUS*

MONTH	MALE	FEMALE
October, 1972	98.8	100.5
November	97.2	100.5
December	98.9	96.8
January, 1973	99.2	97.0
February	100.7	95.9
March	100.9	104.2
April	99.9	100.3
May	100.6	104.0
June	109.1	105.9
July	99.9	100.2
August	100.5	100.3
September	96.4	100.7
October	100.5	103.3
November	101.2	104.0
December	100.1	100.9
January, 1974	100.2	100.2
February	101.4	101.4
March	100.2	101.1
April	100.8	102.2
May	106.4	103.8
June	108.0	104.4
July	101.6	101.6
August	96.5	98.5
September	-	95.9
October	99.4	99.4

TABLE 37

CONDITION WITH GONAD, WITHOUT GONAD AND WITHOUT GONAD AND GUT OF

LABEO GONIUS

Month	MALE					FEMALE				
	Condition (% of max.)	Gonado-somatic index	Condition (minus gonad)	Gastro-somatic index	Condition (minus gonad and gut)	Condition (% of max.)	Gonado-somatic index	Condition (minus gonad)	Gastro-somatic index	Condition (minus gonad and gut)
Oct. 1972	90.68	0.37	90.23	8.01	82.22	95.00	0.43	94.57	5.17	89.40
Nov.	89.10	2.40	86.70	7.95	78.75	95.00	4.38	90.70	5.52	85.18
Dec.	90.70	0.45	90.25	8.44	81.81	91.50	0.47	91.03	6.50	84.53
Jan. 1973	91.00	0.24	90.76	1.58	89.18	91.60	0.40	91.20	2.40	88.80
Feb.	92.40	1.32	91.08	1.34	89.74	90.60	2.70	87.90	1.65	86.25
March	92.50	0.60	91.90	3.68	88.22	98.40	0.54	97.86	6.58	91.28
April	91.60	0.37	91.23	9.37	81.86	94.80	6.35	88.45	6.99	81.46
May	92.30	2.40	89.90	1.48	88.42	98.30	9.68	88.62	1.76	86.86
June	100.00	5.94	94.06	3.90	90.16	100.00	22.37	77.63	5.85	71.78
July	91.60	0.45	91.25	16.43	84.72	94.70	23.06	71.64	0.99	70.65
August	92.20	0.37	91.83	3.30	88.53	94.80	3.79	91.01	1.32	89.69
Sept.	88.40	0.29	88.11	5.45	82.66	95.10	0.39	94.71	5.91	88.80
Oct.	92.20	0.33	91.87	8.02	83.85	97.60	0.59	97.01	6.06	90.95
Nov.	92.80	0.10	92.70	11.47	81.23	98.30	0.05	98.25	8.12	90.13
Dec.	91.80	0.42	91.38	7.89	83.49	95.30	0.50	94.80	6.32	88.48
Jan. 1974	91.80	0.25	91.55	4.52	87.03	94.70	0.40	94.30	4.54	89.76
Feb.	93.00	0.10	92.00	3.67	88.33	95.80	1.84	93.96	3.82	90.14
March	91.90	0.31	91.59	6.65	84.94	95.50	0.49	95.01	7.89	87.12
April	92.40	0.69	90.71	4.33	86.33	96.60	1.36	95.24	3.17	92.07
May	97.60	2.80	94.80	4.50	90.30	98.10	9.52	88.58	3.35	85.23
June	99.00	3.20	95.72	3.37	92.35	98.60	31.30	67.30	2.14	65.16
July	93.20	0.62	92.58	1.65	90.93	96.00	33.43	62.57	0.96	61.61
Aug.	88.50	0.40	88.10	1.52	86.58	93.10	26.27	66.83	0.93	65.90
Sept.	-	-	-	-	-	90.60	1.27	89.33	6.14	83.19
Oct.	91.20	0.43	90.77	1.44	89.33	93.90	0.90	93.00	1.17	91.83

CHAPTER VIII

AGE AND GROWTH

INTRODUCTION

Despite of considerable economic importance of *Labeo gonius*, the author is aware of no published information on its age and growth. This chapter describes the results on the age and growth of the fish.

MATERIALS AND METHODS

Samples for the present study were collected along with *L. bata* from the river Kali and the same methods have been followed for the study of age and growth as employed for *L. bata* (Chapter IV Page 29).

RESULTS AND DISCUSSION

In juveniles the first growth check in the scales occurred in the months of March-April while in adults the growth rings appeared during April to July (Fig. 43). In majority of the fish new rings were added in June. Ring formation during the first year of life appears to be correlated to low feeding intensity in the preceding months while in adults these are spawning marks. This period is also associated with low feeding intensity. In other freshwater fishes similar growth checks have been reported (Pillay, 1953; Qasim, 1957; Radhakrishnan, 1957; Jhingran, 1959;

Natarajan and Jhingran, 1963; Jhingran, 1971; Lakshmanan _et_ _al_., 1971 and Khan and Siddiqui, 1973).

Relationship between fish length and scale length:

A linear relationship was found between the fish length and scale length (Fig. 44). The regression equation expressing this relationship was found to:

$$Y = -1.2127 + 1.0850\ X.$$

The length-frequency distribution of _L_. _gonius_ at each age group as revealed by annuli is given in Table 38. It can be seen that age groups I to IV comprised of moderate number of specimens while fish belonging to age group V and VI were very few (Table 38).

Average calculated length, for each age, absolute growth and growth increment:

The back calculated length from the fishes of different ages and the average lengths at each annulus are given in Table 39. Variation in the calculated and observed length is also represented in Fig. 50. Figure 45 shows the average length at each annulus (Absolute growth curve). It was found that _L_. _gonius_ reaches a size of 142 mm, 206 mm, 239 mm, 264 mm, 285 mm and 300 mm at the age of 1, 2, 3, 4, 5 and 6 years respectively. The absolute growth in length of _L_. _gonius_ is most rapid during the first year of life, thereafter, the rate of growth decreases progressively (Fig. 45).

The times of first growth check, the subsequents ones were found to be different. The first one took place earlier than the later ones. It appears that the first check in growth takes place only due to differential rate of feeding in different seasons thereafter, the intensity of feeding and maturation of gonads affect the growth.

Specific growth rate:

Specific growth rate 'G' was found to be decreased as the age of the fish increased (Table 40, Fig. 46). The decrease in 'G' was only 5.13 between the ages V and VI and 37.20 between the ages I and II.

Fitting growth equation to length at age data:

The method developed by Ford (1933) and Walford (1946) of plotting Lt + 1 against Lt is followed here (Fig. 47). The calculated asymptotic length ($L\alpha$) is 449 mm. The pattern of growth in L. gonius conforms to the Von Bertalanffy's growth equation. The equation which describes the inverse exponential pattern of growth is :

$$Lt = L\alpha \left(1 - e^{-K\,(t - t_0)}\right)$$

Where Lt = length at age t, $L\alpha$ = ultimate length, 'e' = base of neparian logarithm, K = a constant, t = age of fish, 't_0' = arbitrary origin of the growth curve.

The values estimated for these parameters are:

$$L\alpha = 449 \text{ mm}$$
$$K = 0.2099$$
$$'t_0' = -0.6940$$

The value of 't_0' was calculated (Fig. 48) after Ricker (1958).

Substituting the values of $L\alpha$, K and 't_0' to the Von Bertalanffy's growth equation for L. gonius, it could be expressed as

$$Lt = 449\ (1-e^{-0.2099\ (t\ +\ 0.6940)})$$

The values of Lt at different ages were calculated and tabulated in table 40.

Seasonal growth:

Seasonal growth was found to be mainly influenced by feeding intensity in the fishes of first year-class while in adults fishes the seasonal growth curve was affected by feeding intensity as well as the maturation of gonads. The seasonal growths of the fishes of first year, second year and third year-classes showed similar growth pattern in different seasons (Table 41, Fig. 49) as in the case of L. bata (Chapter IV).

SUMMARY

The age and growth of L. gonius (Ham.) was investigated by the analysis of scales. It attained an average length of 142 mm, 206 mm, 239 mm, 264 mm, 285 mm and 300 mm at the age of 1, 2, 3, 4, 5 and 6 years respectively. A straight line relationship was obtained between the scale length and body length as expressed by the following equation:

$$Y = -1.2127 + 1.0850\ X$$

The Von Bertalanffy's growth equation was found to describe adequately the actual growth of the species and could be expressed as:

$$Lt = 449\ (1-e^{-0.2099\ (t\ +\ 0.6940)})$$

Fig. 43. Percentage of scales of _L. gonius_ with marginal rings.

Fig. 44. Total length scale length relationship of _L. gonius_.

Fig. 45. The growth curve of _L. gonius_.

(The upper curve represents the average length at each age and the lower curve represents the average growth increment at each age).

Fig. 46. Change in the instantaneous (specific) growth rate (expressed as percent of length per annum) of _L. gonius_ with age.

Fig. 47. Ford Walford plot of growth of _L. gonius_.

Fig. 48. $\log_e(L\infty - l_t)$ plotted against age for estimation of 't_0' in _L. gonius_.

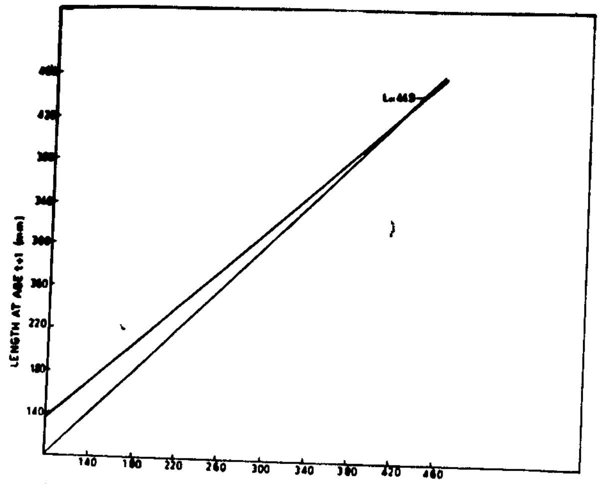


FIG47

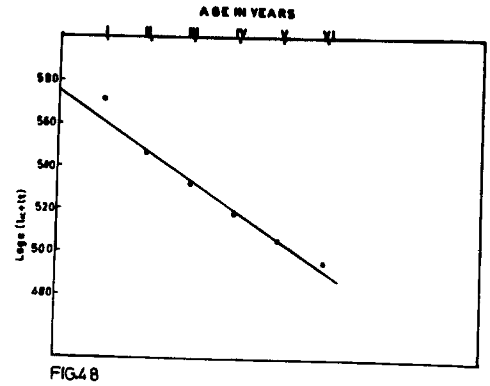


FIG48

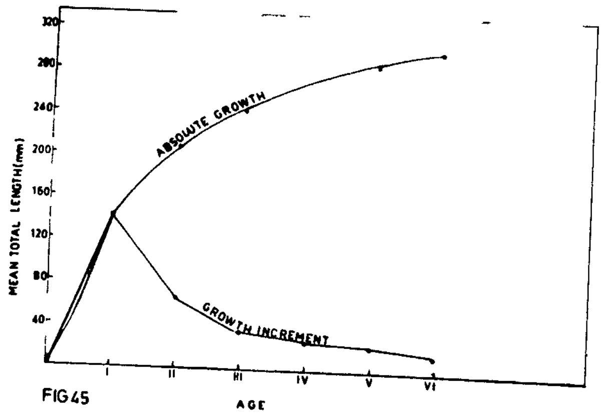


FIG45

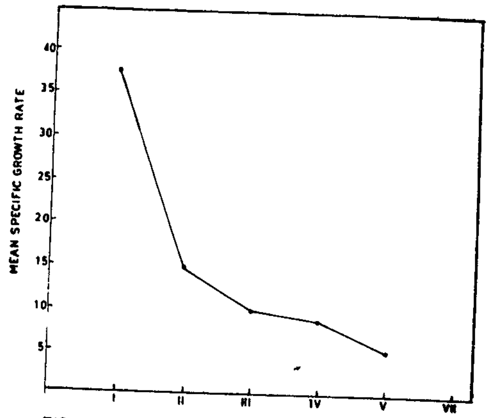


FIG.46

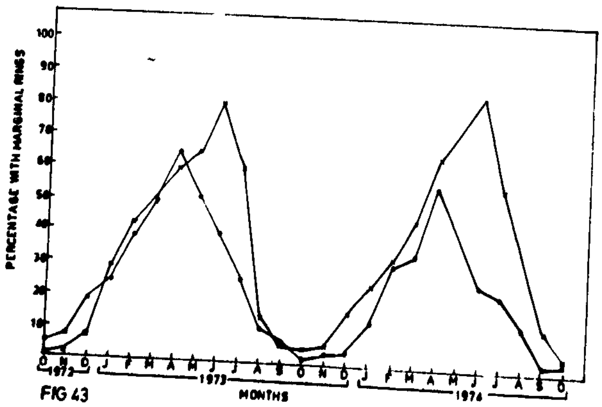


FIG 43

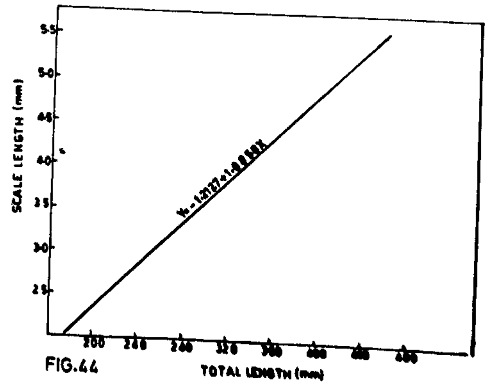


FIG.44

Fig. 49. Seasonal growth curve of L. gonius.

Fig. 50. Variation in the back calculated and observed length of L. gonius.

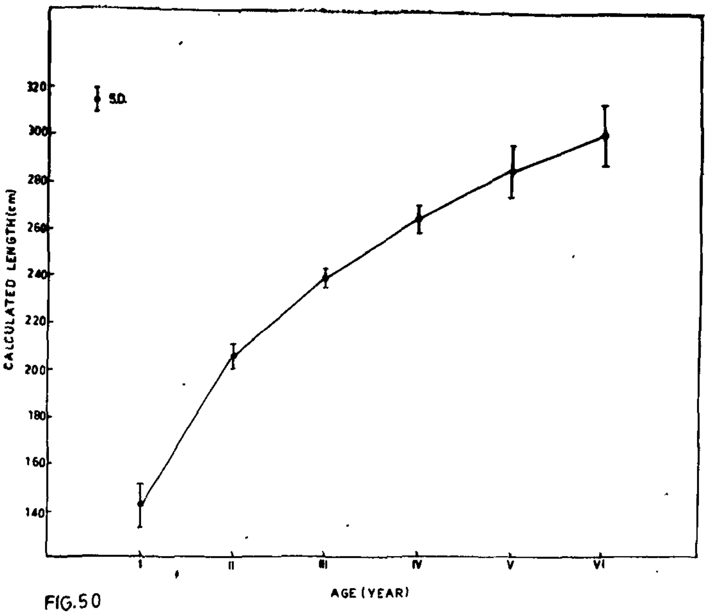

S.D.
CALCULATED LENGTH (cm)
320
300
280
260
240
220
200
180
160
140
I
II
III
IV
V
VI
AGE (YEAR)

FIG.50

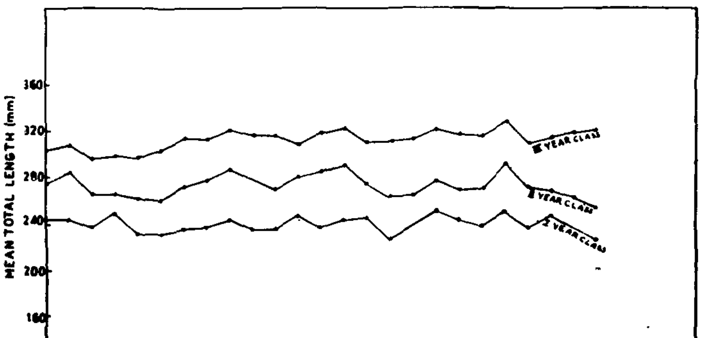

MEAN TOTAL LENGTH (mm)
360
320
280
240
200
160
O N D J F M A M J J A S O N D J F M A M J J A S O
1972
1973
1974
MONTHS

FIG.49

TABLE - 38

LENGTH FREQUENCY DISTRIBUTION OF AGE GROUPS OF *L. GONIUS*

Size groups (mm)	AGE GROUPS					
	I	II	III	IV	V	VI
150 - 200	4	-	-	-	-	-
201 - 250	88	9	3	-	-	-
251 - 300	2	66	10	-	-	-
301 - 350	-	3	51	6	2	-
351 - 400	-	-	3	42	7	1
401 - 450	-	-	-	-	6	5
Total number of fishes	94	78	64	48	15	6
Percent of total	30.7	25.8	20.9	15.6	4.9	1.9

TABLE - 39

CALCULATED LENGTH AT EACH ANNULUS AS DETERMINED BY BACK CALCULATION

Age	Calculated length at different annuli (mm)					
	I	II	III	IV	V	VI
1	180	-	-	-	-	-
2	164	225	-	-	-	-
3	137	212	259	-	-	-
4	134	201	240	277	-	-
5	124	201	231	265	290	-
6	118	192	225	252	281	300
Grand Mean	142	206	239	264	285	300

TABLE - 40

MEAN CALCULATED LENGTH AT EACH ANNULUS, GROWTH INCREMENT, RELATIVE GROWTH AND SPECIFIC GROWTH RATE

Age group	Back calculated length (mm)	Length determined by growth equation	Growth increment (mm)	Relative growth (%)	Specific growth (%)
I	142	131	142	47.3	37.20
II	206	174	64	21.3	14.85
III	239	223	33	11.1	9.94
IV	264	263	25	8.3	7.64
V	285	283	21	7.0	5.13
VI	300	296	15	5.0	

TABLE 41

MEAN MONTHLY GROWTH RATE OF <u>L. GONIUS</u>

Months	FIRST YEAR		SECOND YEAR		THIRD YEAR	
	Mean length (mm)	% of total annual growth	Mean length (mm)	% of total annual growth	Mean length (mm)	% of total annual growth
October 1972	242	-	275	-	303	-
November	243	0.4	284	3.2	308	1.6
December	236	-2.8	265	4.2	295	4.2
January 1973	248	-5.0	265	-6.6	297	0.6
February	230	-7.2	261	--	298	0.3
March	230	-	259	-1.5	296	-0.6
April	234	1.7	270	-0.7	302	2.0
May	236	0.8	276	4.2	312	3.3
June	242	2.5	286	2.2	312	-
July	234	-3.3	-	3.6	320	2.5
August	234	-	269	-	316	-1.2
September	244	4.2	279	3.7	315	0.3
October	235	-3.6	283	1.4	317	0.6
November	242	2.9	290	2.4	321	1.2
December	244	0.8	274	-5.5	310	-3.4
January 1974	225	-7.7	264	-3.6	-	-
February	-	-	264	-	302	-2.5
March	248	9.3	275	4.1	320	5.9
April	241	-2.8	269	-2.1	316	-1.2
May	237	-1.6	269	-	316	-
June	250	5.4	290	7.8	328	3.7
July	236	-5.6	270	-6.8	309	-5.7
August	245	3.8	268	0.7	313	1.2
September	-	-	262	2.2	318	1.5
October	222	-9.3	252	-3.8	321	0.9

CHAPTER IX

FOOD AND FEEDING HABITS

INTRODUCTION

One of the most important aspect of study of the biology of fish is to determine its food and feeding habits. Food composition, intensity of feeding and its variations with season, size and sex of L. gonius is being reported here.

MATERIALS AND METHODS

Samples of L. gonius were obtained from the river Kali. The same methods were followed as reported for L. bata (Chapter V, Page 53).

RESULTS AND DISCUSSION

Absence of teeth, narrow mouth, depressed buccal cavity, absence of tongue, modification of gill rakers for filtration, absence of stomach and presence of large gut indicated the herbivorous feeding habit of this fish. The analysis of gut contents of this fish for consecutive months showed that this fish mainly feeds on small phytoplankton and decayed organic matter.

FOOD COMPOSITION:

Seasonal variations in the composition of gut contents of L. gonius becomes quite apparent from Table 42 and Fig. 51. Phytoplankton was found to be the main food of the adult fish. It formed about 45% of the total food consumed.

DIATOMS (Bacillariophyceae):

The diatoms were represented by 9 genera which formed the chief food of the fish and constituted about 18.6% of the total food. This group was more abundant in the food from October to March and comparatively lesser percentage occurred from April to August. The percentage of diatoms was very low in June. Navicula, Cyclotella, Nitzschia, Gyrosigma, Cymbella and Diatoma were the most important diatoms as food and occurred in the decreasing order. From September to April, Navicula was encountered abundantly while from May to August it was extremely scarce. Nitzschia was frequently found throughout the year except during May, June and July (Table 42, Fig. 51).

GREEN ALGAE (Chlorophyceae):

In L. gonius green algae represented by 8 genera, constituted about 8.6% of the total food and occurred throughout the year in the gut content. They were more abundant during January, March, April, May and December and less abundant in July. The most important genera were Scenedesmus, Ankistrodesmus, Crucigenia and Tetraspora. The lesser important genera were Oedogonium, Pediastrum, Selenastrum and Spirogyra (Table 42, Fig. 51).

BLUE GREEN ALGAE (Myxophyceae):

This group comprised of Nostoc, Anabaena, Microcystis and Phormidium formed 5.2% of the total food. Microcystis and Phormidium were more common. Myxophyceae was predominant in July and September.

Other food items:

Desmids, phytoflagellates, algal spores and zygotes and macrovegetation were also encountered in the guts of L. gonius (Table 42, Fig. 51). These items together formed 13.7% of the total food. Zooplankton occurred in very small quantities and it appears that they accidently entered alongwith the phytoplankton.

Decayed organic matter:

This group mainly consisted of unidentifiable plant matter in decayed condition and constituted about 16.4% of the total food. It occurred regularly in the guts throughout the year.

Sand and mud:

It formed 35.4% of the total food and occurred in the guts throughout the year. It constituted the main bulk of the gut contents (Table 42, Fig. 51).

A gradual increase in the percentage of phytoplankton along with sand and mud in the gut contents with increase in size of the fish reveals that this species changes its feeding habit as it grows (Table 43, Fig. 52). The occurrence of large quantities of decayed organic matter together with sand and mud in the guts indicate that the fish feeds at the bottom.

No difference was found in food composition of males and females.

INTENSITY OF FEEDING:

The values of gastro-somatic index along with the percentage of empty guts for different months are given in Table 44 and Fig. 53. A pronounced feeding activity was recorded from October to March. The feeding intensity was extremely low during July and August.

In both the sexes the intensity of feeding was high in immature, maturing and spent fishes and low in ripening and ripe fishes. The feeding intensity was found to be better in the males than in the females throughout the year, especially in the spent fishes (Table 46, Fig. 54).

The relative percentages of different food items varied from month to month and a particular type of food item tended to be maximum at a particular time, perhaps due to its abundance in the environment at that time. There appears to be definite preference for any particular species or genera of phytoplankton. Generally the small sized phytoplankton and decayed organic matter were preferred.

Seasonal variations in the rate of feeding appear to be affected by temperature and flooding of the river as low food intake was recorded during monsoon months (June, July and August) and high rate of feeding during rest of the months. The feeding intensity was also influenced by the state of maturation of gonads.

SUMMARY

L. gonius (Ham.) feeds mainly on phytoplanktonic organisms. Diatoms, green algae and decayed organic matters were the main food items present in the gut. The presence of sand and mud in the gut content showed a bottom feeding habits. The intensity of feeding was found to be maximum during post monsoon and winter months (October - February) and low feeding during post winter and monsoon months (March to August). Maturation of gonads also adversely affected in both the sexes, the feeding intensity. The fish showed a positive selection for all the phytoplanktonic organisms.

Fig. 51. Seasonal variations in the percentage composition of food of *L. gonius*.

Fig. 52. Intensity of feeding at different size groups of *L. gonius*.

Fig. 53. Seasonal variations in the intensity of feeding of *L. gonius*.

Fig. 54. Intensity of feeding at different maturity stages of *L. gonius*.

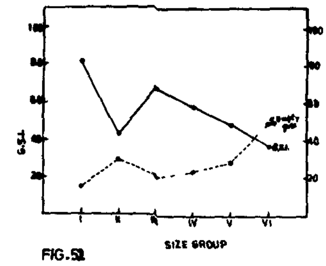


FIG.52

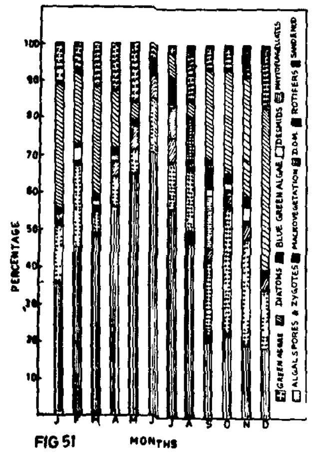


FIG 51

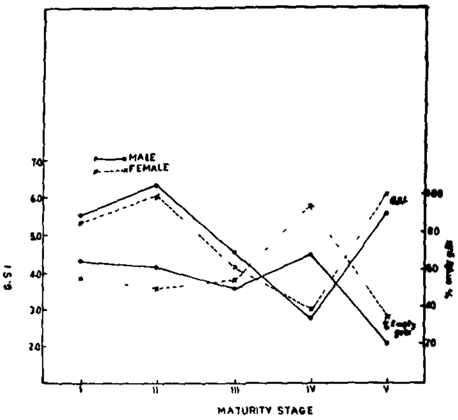


FIG 54

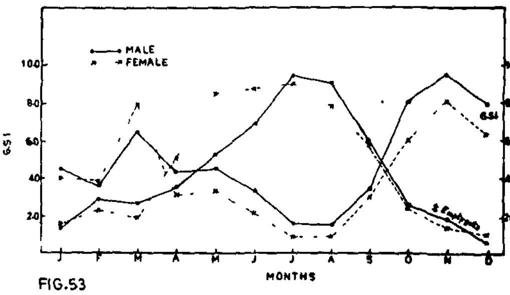


FIG.53

TABLE 42

...ONS IN THE PERCENTAGE COMPOSITION OF DIFFERENT FOOD ITEMS OF LABEO GONIUS

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
0.6	0.2	0.9	0.4	0.1	-	0.6	-	-	0.2	0.3	0.5	0.5
0.5	0.1	0.4	0.2	-	-	0.1	0.2	1.0	0.1	0.2	0.4	0.4
-	-	0.2	-	-	0.1	-	1.3	0.2	0.3	-	0.7	0.5
2.5	-	0.2	0.3	0.2	0.2	0.1	0.2	1.8	1.1	2.5	4.2	0.8
1.2	-	0.2	6.9	5.2	1.7	0.9	1.6	2.5	2.1	4.2	5.1	2.0
3.1	-	5.2	11.3	7.9	2.2	0.8	1.9	0.9	-	0.1	0.8	1.7
-	5.2	-	-	-	-	-	-	0.1	-	1.2	2.1	0.5
3.2	1.2	4.1	3.8	2.5	1.3	-	-	-	2.9	-	3.1	2.2
11.1	6.7	11.2	12.9	15.9	4.5	2.4	5.2	6.8	6.7	8.5	15.9	8.6
8.2	3.1	0.4	3.5	0.5	0.2	1.9	2.1	4.0	9.5	11.5	11.9	3.3
0.7	3.5	3.1	1.9	1.1	0.1	0.9	1.0	3.1	0.8	0.7	1.1	1.6
1.3	1.1	1.7	1.5	0.8	0.2	1.8	2.6	2.1	6.2	5.2	4.1	2.2
13.1	10.5	11.5	5.2	2.5	0.9	0.8	2.1	4.8	7.8	10.5	12.2	3.9
2.5	0.8	0.5	0.3	0.3	0.1	1.2	2.0	3.8	-	-	0.3	1.9
4.5	3.7	2.1	0.9	-	0.2	-	-	2.0	1.9	2.1	8.5	2.3
3.8	0.5	10.2	0.9	0.2	-	-	-	0.9	1.2	1.8	3.1	1.6
-	-	0.4	0.8	-	-	-	0.1	0.5	-	0.2	0.1	0.3
-	2.1	0.2	-	-	-	-	-	2.8	-	0.1	0.1	1.5
34.1	21.3	30.1	15.1	5.4	1.7	6.6	9.9	24.0	27.4	32.1	43.4	18.6
-	0.2	-	0.1	-	-	0.9	0.1	0.8	0.3	0.2	0.1	0.5
-	-	0.2	-	-	-	-	-	1.5	-	1.1	-	0.8
-	0.3	-	0.4	0.2	-	3.8	2.0	2.5	-	-	0.2	2.1
0.4	0.1	-	1.1	0.8	-	2.5	2.1	1.9	2.2	1.1	-	1.8
0.4	0.6	0.2	1.6	1.0	-	7.2	4.2	7.7	2.5	2.3	0.3	5.2
0.2	1.3	1.5	-	-	-	0.2	0.3	0.6	-	-	-	0.3
2.1	2.8	0.2	-	-	-	-	1.3	0.7	2.4	0.1	5.2	1.1
2.3	4.1	1.7	-	-	-	0.2	1.6	1.5	2.4	4.1	1.2	1.4
0.4	-	-	-	-	-	-	-	0.1	-	0.1	-	0.1
0.4	-	-	-	-	-	-	-	0.1	-	0.1	-	0.1
0.2	-	1.4	1.9	-	2.1	8.2	10.5	14.5	1.2	0.8	0.3	8.5
2.1	0.9	5.5	4.2	6.2	6.5	6.5	2.0	2.8	3.5	4.1	3.8	3.7
13.5	22.2	6.2	8.2	6.7	13.2	12.8	16.5	20.2	33.7	28.5	15.5	16.4
-	-	0.2	-	-	-	-	2.8	1.5	0.2	-	-	2.1
-	-	0.2	-	-	-	-	2.8	1.5	0.2	-	-	2.1
35.9	45.2	48.5	56.1	64.8	72.0	56.1	47.3	20.9	22.4	19.5	18.6	35.4

MONTHLY VAR

Food items
Oedogonium
Pediastrum
Selenastrum
Ankistrodesmus
Scenedesmus
Spirogyra
Tetraspora
Crucigenia
GREEN ALGAE
Cyclotella
Diatoma
Nitzschia
Navicula
Cymbella
Gyrosigma
Cocconeis
Synedra
Surirella
DIATOMS
Nostoc
Anabaena
Microcystis
Phormidium
BLUE GREEN ALGAE
Cosmarium
Closterium
DESMIDS
Volvox
PHYTOFLAGELLATES
ALGAL SPORES & ZYGOTES
MACROVEGETATION
DECAYED ORGANIC MATTER
Keratella
ROTIFERS
SAND AND MUD

TABLE - 43

VARIATIONS IN THE FOOD COMPOSITION OF <u>LABEO GONIUS</u> IN RELATION TO SIZE

FOOD ITEMS	SIZE GROUPS					
	I (150-200)	II (201-250)	III (251-300)	IV (301-350)	V (351-400)	VI (401-450)
Green algae	-	11.7	10.1	10.4	8.7	10.2
Diatoms	-	19.5	31.3	31.4	8.6	3.7
Blue green algae	-	0.4	1.2	0.9	1.6	1.0
Desmids	-	1.2	2.5	2.5	-	-
Phytoflagellates	-	-	0.3	1.2	2.1	2.2
Algal spores and zygotes	-	1.7	0.7	1.4	1.9	-
Macrovegetation	-	3.9	2.5	2.4	5.3	6.4
Decayed organic matter	-	10.5	19.7	19.9	10.7	10.5
Rotifers	-	-	0.2	0.2	-	-
Sand and Mud	-	31.8	31.5	29.7	61.1	66.0

TABLE - 44

SEASONAL VARIATIONS IN THE INTENSITY OF FEEDING OF *L. GONIUS*

Months	MALE		FEMALE	
	G.S.I.	% empty guts	G.S.I.	% empty guts
Jan.	4.52	14.5	4.04	15.1
Febr.	3.67	29.0	3.82	23.5
March	6.65	26.8	7.89	19.0
April	4.33	35.0	3.17	50.0
May	4.50	52.0	3.35	85.2
June	3.37	68.6	2.14	87.5
July	1.65	94.0	0.96	90.2
August	1.52	90.0	0.93	78.0
Sept.	3.45	60.0	2.98	58.2
Oct.	8.02	25.8	6.06	24.5
Nov.	9.47	18.2	8.12	13.5
Dec.	7.89	5.1	6.32	9.5

TABLE - 45

VARIATIONS IN THE INTENSITY OF FEEDING WITH SIZE

Size group (mm)		Gastro-somatic index	% empty guts
I	150-200	8.2	15.0
II	201-250	4.3	29.2
III	251-300	6.8	20.9
IV	301-350	5.8	23.1
V	351-400	4.9	28.6
VI	401-450	3.8	49.8

TABLE - 46

VARIATIONS IN THE INTENSITY OF FEEDING WITH MATURITY STAGES

Maturity stages	Sex	Gastro-somatic index	% empty guts
I	Male	5.5	65.1
	Female	5.3	56.0
II	Male	6.3	62.3
	Female	6.0	50.0
III	Male	2.2	50.0
	Female	4.1	55.0
IV	Male	2.7	68.0
	Female	2.9	94.0
V	Male	5.5	20.0
	Female	6.0	34.0

CHAPTER X

REPRODUCTION

INTRODUCTION

The present study gives a detailed account of sex ratio, size and age at first maturity, maturation and spawning, breeding season and the fecundity of *L. gonius*.

MATERIALS AND METHODS

Samples which formed the basis of the present investigation were collected from the river Kali over a period of 13 months, from October 1972 to October 1973. The same methods were followed here for the study of various aspects of the reproductive biology of *L. gonius* as described by Siddiqui, *et al.*, 1976. for *L. bata* (see also Chapter VI, Page 70).

RESULTS

Sex distribution of *L. gonius* in different months is shown in Table 47 and at different ages in Table 48. The total number of fishes sexed was 356, of which 124 were males and 232 females. The ratio between males and females on the whole was 1:1.86. In case of sex composition at various ages groups, a preponderance of males over females was recorded in age group I, whereas in subsequent age groups females were more abundant. In age group VI no male was recorded.

Size at First Maturity

The gonads were classified into five stages of maturity according to the scheme of classification as described for Ophicephalus punctatus (Qayyum & Qasim, 1964).

The fishes falling in different maturity stages are tabulated in Table 49. All fishes below 160 mm were immature (stage I). The smallest ripe male was 170 mm in length and the smallest ripe female was 180 mm. Both sexes attained sexual maturity after completing first year of their life.

Spawning cycle

Fig. 55 shows the percentage of fishes at various maturity stages in different months of the year. Both sexes showed a regular seasonal change in their maturity stages. The gonads of maturing virgins and recovered spent fishes started ripening in March and this stage became dominant in April and May. In June almost all fishes were ripe and in late July spent fishes began to appear. The percentage of spent fish increased in August and all were spent in September. The occurrence of spent fish in late July showed the commencement of spawning and as all fish in the September sample were spent it may be assumed that spawning was completed by the end of August.

Spawning periodicity

Ova diameter frequencies of L. gonius (Fig. 56) showed that the ovaries contain a single batch of eggs, suggesting that each individual spawns only once during the breeding season. In March when the fish started ripening, the average size of ova was 0.18 mm. In April, the size of ova increased markedly and the modal size was found to be at 0.22 mm. The mode shifted to 0.80 mm in May and to 1.20 mm in June. Almost all the ova were discharged in July and August.

Seasonal changes in gonad weight

Seasonal changes in gonad weight are diagrammatically represented in Fig. 57. The weights of gonads are expressed as percentage of body weight. The curves of male and female gonads showed almost the same pattern but the seasonal changes in testes weight were less marked.

The testes remained in a resting condition till January and maturation started only in February. From March onward a gradual increase in testes weight was observed and the maximum weight was recorded in June. In July it decreased and reached its minimum level in September.

The ovaries gained appreciable weight in March. A rapid increase in ovarian weight was recorded in April and May with its maximum in June. A decrease occurred in July and continued upto September. Thereafter no appreciable change was noted until January.

Fecundity

The number of eggs produced by 30 ripe females of 185 to 435 mm in length and belonging to age groups 1+ to VI ranged from 9,309 to 3,45,657 with an average of 96,477. Number of ova per g body weight, per g ovary weight and per mm body length were 744, 1,473 and 801 respectively and did not vary in different regions of the two ovaries.

Fecundity and total length

A non-linear relationship was obtained for length and fecundity (Fig. 58a). The two values plotted on logarithmic paper produced a straight line (Fig. 58b) and the values calculated for this relationship were as follows:

$$\text{Log } F = -0.8051 + 3.693 \text{ Log } L \quad (F = \text{fecundity}, L = \text{length})$$

Fecundity and body weight

The relationship between fecundity and body weight was found to be linear (Fig. 59) and could be expressed by the following regression equation:

$$\text{Log } F = 1.2733 + 1.3335 \text{ Log } W \quad (W = \text{body weight})$$

Fecundity and ovary weight

A direct relationship was also found between the values of fecundity and ovary weight (Fig. 60). The regression equation for this relationship is:

$$\text{Log } F = 3.6886 + 0.6367 \text{ Log O.W.} \quad (\text{O.W.} = \text{ovary weight})$$

Fecundity and age

Fig. 61 shows the relationship between age and fecundity, No appreciable change in egg production potential took place upto IV years, thereafter the fecundity increased considerably. The following regression equation was obtained:

$$\text{Log } F = 4.5076 + 1.8325 \text{ Log } A \quad (A = \text{age})$$

DISCUSSION

From the observations of the maturation and depletion of gonads, seasonal changes in gonad weight and intra-ovarian oocytes, it becomes quite evident that individual L. gonius spawn only once in a breeding season, which continues through July and August. Other cyprinid fishes from Northern India have also been reported to spawn in these two months (Khan 1924, 1942 and Qasim & Qayyum, 1961).

Spawning appears to be directly related to the monsoon cycle and as the onset of monsoon is delayed in Northern India, spawning is also delayed. On the other hand, breeding seasons of cyprinid fishes in Eastern India, where the monsoon breaks out early, last from April to August (David, 1959).

The overall sex ratio between the males and females was 1:1.86. The males were dominant upto the length of 200 mm whereas the females become dominant in higher size groups. In the 370 -

430 mm group, the complete exclusion of males took place. The preponderance of females in higher size groups appears due to heavy mortality of males in the smaller size groups, either natural death or to fishing pressure, as they are more active and thus caught more easily. The dominance of males among smaller size fish and females in larger ones has been reported in a number of fish species (McFadden et al., 1962; Bailey, 1963; Bhatnagar, 1972). Makeeva & Nikolskii (1965) pointed that the sex ratio differs at different sizes and age groups even in species with overall 1:1 ratio.

The males matured earlier than the females. Running ripe males continued to occur till early September whereas the females were completely spent by the end of August. The prolongation in the ripe stage of males ensures the fertilization of the maximum number of eggs. Similar observations have been made in Blennius pholis (Qasim, 1957) and L. gonius and Cirrhina mrigala (Parameswaran et al., 1970). Males also attained maturity at a smaller size than the females and this has been related to shorter life span and smaller maximum size of males (Makeeva & Nikolskii, 1965).

The size of mature ova was almost the same in all the fish studied, confirming the observations of Khan (1972) in the case of Labeo rohita. However, Simpson (1951) in Pleuronectes platessa and Wydoski & Cooper (1966) in Salvelinus fontinalis reported variations in the size of mature ova.

Fecundity was found to vary considerably from fish to fish. Nikolskii (1963) attributed the variations in fecundity to conditions of life and environmental conditions. Fecundity is directly related to size and weight of the fish and growth in both dimensions is related to food supply. Therefore, the dependency of fecundity on food becomes quite apparent. Bagenal (1957) also came to the same conclusion in Hippoglossoides platessoides.

Fecundity was found to be more closely related to body weight and ovary weight than the length of the fish. Generally a non-linear relationship between length and fecundity, as in the present case, has been reported in a number of fish species (Raitt, 1933; Hickling, 1940; Allen, 1951; Simpson, 1951 and Bagenal, 1957). On the other hand Lehman (1953) found a linear relationship in American shad as did Bhatnagar (1972) in Labeo fimbriatus. Fecundity has often been found to be related to the square of the length (Franz, 1910; Kisselevitch, 1923; Clark, 1934). Simpson (1951) found a cube relationship between fecundity and length in plaice and this relationship with slight variation has been found to be true in many other species (Pillay, 1954; Sarojini, 1957; Jhingran, 1961; Qasim & Qayyum, 1963 and Khan, 1972). The fecundity of L. gonius was found to vary at a rate of 3.6963 power of the length. This signifies a high fecundity in this species.

Fecundity continued to increase with age and did not decline in older age groups as was found in Labeo rohita by Khan (1972). This appears to be a characteristic feature of small and medium sized fishes because Qasim & Qayyum (1963) also reported positive heterogonic growth in the ovaries of three fish species (Ophicephalus punctatus, Barbus stigma and Callichrous bimaculatus).

Fecundity was found to have linear relationship to body weight and ovary weight, at a power almost equal to unity. In other words the number of eggs in the ovaries increases in proportion to the fish weight and gonad weight.

SUMMARY

Sex ratio, size and age at first maturity, maturation and spawning, breeding season and fecundity of L. gonius were investigated in the river Kali.

The overall sex ratio between males and females was 1:1.86. Males were dominant in the smaller size groups and the females in larger ones. Males matured earlier than the females, at a length of 170 mm while females matured at 180 mm. Both sexes at this size belonged to 1+ age group.

Only one stock of oocytes were present in the ovary. Each individual spawned only once in a season which lasted from July to August.

The average fecundity was 96,477. It increased proportionately with body and gonad weight and at the power of 3.6963 to that of body length.

Fig. 55. Percentage of _L_. _gonius_ at each of the five stages of maturity.

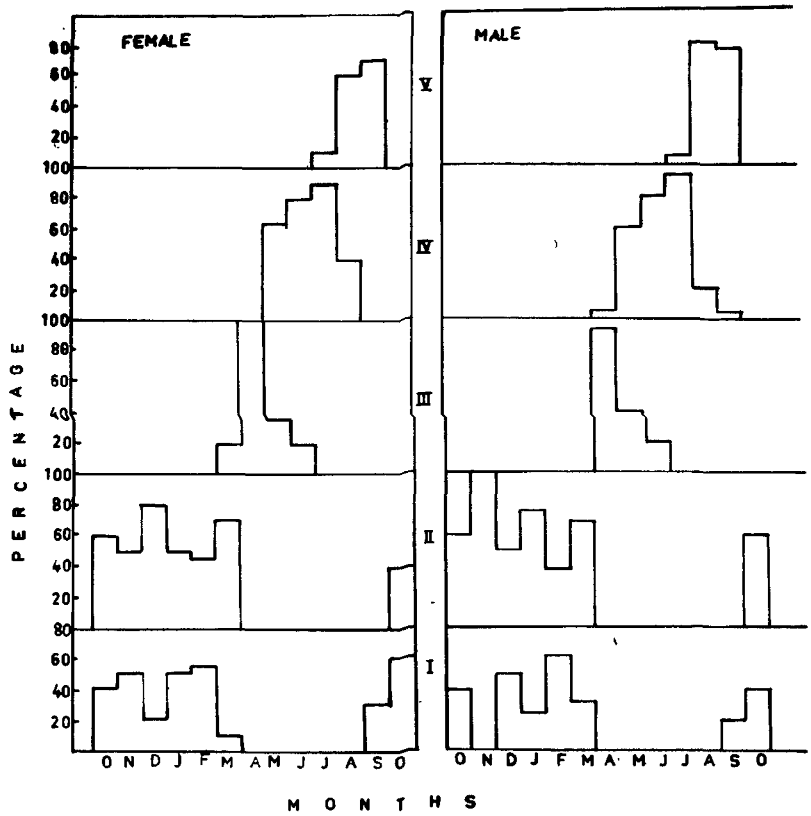


FIG. 55

Fig. 56. Size frequency distribution of intra-ovarian oocytes of _L. gonius_ from March to July.

Fig. 57. Seasonal variation in gonad weight on percentage of body weight of _L. gonius_.

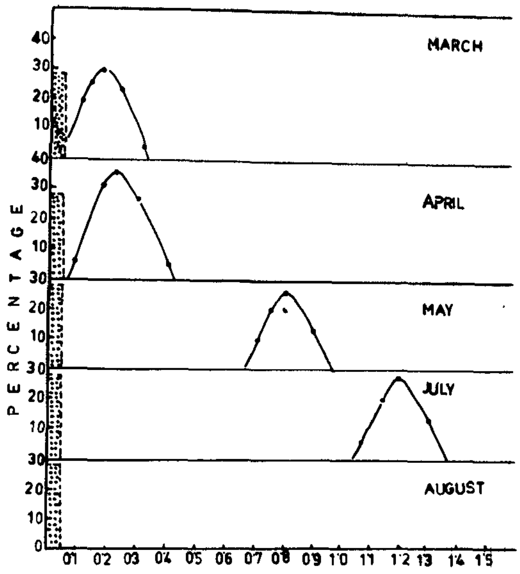


FIG.56 OVA DIAMETER (mm)

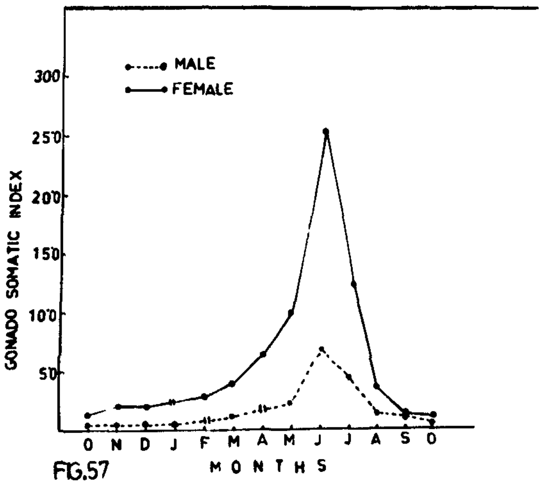


FIG.57 MONTHS

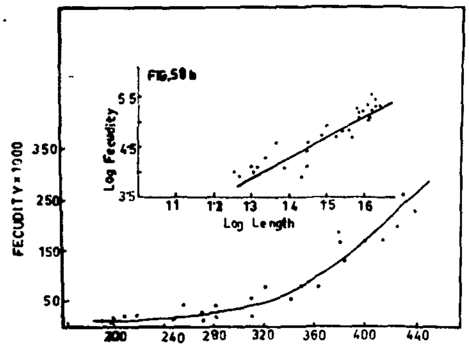


FIG. 58a

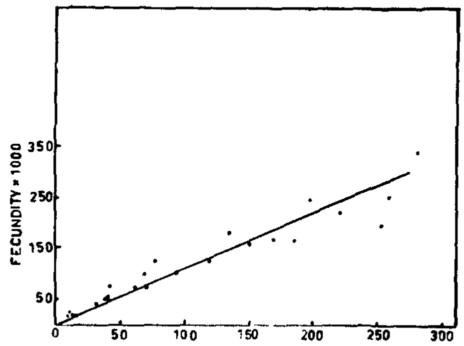


FIG.60

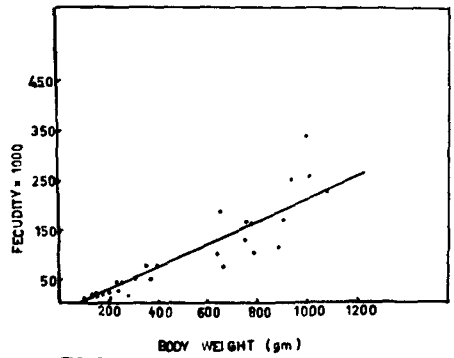


FIG.59

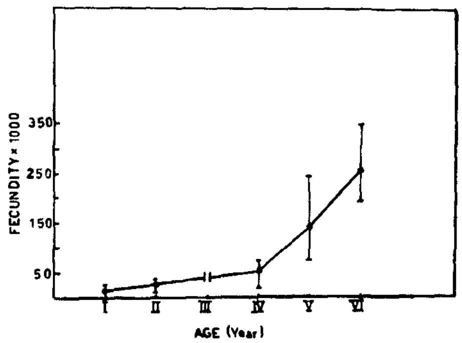


FIG.61

TABLE - 47

NUMBER OF PERCENTAGE OF MALES AND FEMALES IN DIFFERENT MONTHS

Months	No. of Males	No. of Females	% of Males	% of Females	Sex Ratio
Oct.	8	16	33.3	66.7	1:2
Nov.	4	8	33.3	66.7	1:2
Dec.	20	32	38.4	61.6	1:1.6
Jan.	4	16	20.0	80.0	1:4
Feb.	20	24	45.4	54.6	1:1.2
March	4	32	11.1	88.9	1:8
April	8	4	66.6	33.4	1:0.5
May	12	20	37.5	62.5	1:1.66
June	20	20	50.0	50.0	1:1
July	4	8	33.3	66.7	1:2
Aug.	8	20	28.5	71.5	1:2.5
Sept.	4	16	20:0	80.0	1:4
Oct.	8	16	33.3	66.7	1:2
Total	124	232	34.9	65.1	1:1.86

TABLE - 48

NUMBER AND PERCENTAGE OF MALES AND FEMALES AT VARIOUS AGE GROUPS

Age groups	No. of Males	No. of Females	% of Males	% of Females	Sex Ratio
I	44	36	55.0	45.0	1:0.82
II	40	84	32.3	67.7	1:2.09
III	8	40	16.7	83.3	1:5
IV	12	36	25.0	75.0	1:3
V	4	28	12.5	87.5	1:7
VI	-	12	-	100.0	0:1

Note: Chi-square test rejects Nulls hypothesis that both sexes are equally distributed in the population.

TABLE 49

MATURITY STAGES IN VARIOUS LENGTH GROUPS (mm) OF L. GONIUS

Length (mm)			150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350	360	370	380	390	400	410	420	430
MATURITY STAGES	MALE	I	10	8	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		II	-	-	-	5	1	4	1	2	1	2	3	1	-	2	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-
		III	-	-	2	4	6	2	5	1	1	-	-	1	1	-	1	-	-	1	1	-	-	-	-	-	-	-	-	-	-
		IV	-	-	1	-	2	2	1	2	1	-	3	4	6	1	2	-	1	-	2	1	1	1	-	-	-	-	-	-	-
		V	-	-	-	1	3	3	1	-	2	2	-	-	-	1	1	1	-	1	-	-	1	-	-	-	-	-	-	-	-
	FEMALE	I	7	6	7	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		II	-	-	-	1	1	1	2	2	1	4	5	4	6	8	7	3	1	1	2	1	-	1	3	2	1	-	-	-	-
		III	-	-	-	2	3	-	1	1	--	1	2	4	4	4	1	2	2	1	1	2	1	2	1	2	2	2	-	-	-
		IV	-	-	-	1	2	1	3	5	8	2	1	2	3	4	4	5	2	2	2	1	4	2	1	1	1	3	2	3	1
		V	-	-	-	-	2	5	3	2	7	3	2	2	2	3	2	2	2	1	1	1	2	-	-	-	1	1	-	-	-

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